Steel

In Pursuit of the Increasing Value of “Quantity" and the Enduring Value of “Quality"

March, 2024

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Summary

- Steel, which can be procured inexpensively, will remain an essential manufacturing industry for Japan because it is used for a variety of purposes, including as a structural material, and also because it plays an important role in security. However, in addition to Japan's declining population, changes in industrial structure in terms of both "quantity" and "quality" are inevitable due to structural changes in the automobile industry (local production for local production, electrification/intelligence, and the spread of gigacasting, etc.)
- As for the impacts on "quantity", a decline in domestic crude steel production is likely. Crude steel production in 2050 is projected to be 50 to 67 million tons due to shrinking domestic demand caused by population decline and due to export difficulties caused by local production for local consumption in finished vehicle manufacturing and by local procurement of parts and materials
- As for the impacts on "quality", there will likely be a lowering of barriers to overseas general-purpose products. In terms of quality, *tsukurikomi*[1] and *suriawase*[2] have traditionally been strengths of Japanese companies, but, with the progress in electrification and intelligence in the automobile industry, there may be decreased opportunities for and diluted effectiveness of *tsukurikomi* and *suriawase*. The widespread implementation of CPS will also accelerate these impacts
- It is assumed that *tsukurikomi* and *suriawase* will not disappear because new functionality will be required as electric vehicles become more widespread. However, *tsukurikomi* and *suriawase* are small in scale and require constant research, so a strategy of only competing with high value-added products (=quality) is not feasible, and the basic route will be to compete in the volume zone (=quantity), which is the cash cow
  - When competing on "quality", it is important to make maximum use of strengths such as advanced material processing/material property knowledge and possession of high-quality analysis data
- The winning strategies for Japanese companies appear to be in the following directions (combinations of these strategies are also possible)
  1. By securing "quantity" on a global basis and becoming an industry insider in each region, companies can respond to the industry trend of local production for local consumption. Strengthen quality based on the cash obtained through this process. Aim to become one of the global steel majors by acquiring overseas steel manufacturers
  2. Aim to secure quantity in the domestic market and maintain a firm position, and lead restructuring of domestic companies in order to do so. Using the cash and technologies obtained domestically, partner with overseas local steel companies and support their growth by providing technologies
  3. Expand to non-steel materials (aluminum and rare metals, etc.), engineering, and downstream businesses (components and vehicle body manufacturing)
- Furthermore, considering 2050 crude steel production volumes, some steel manufacturers will not be able to maintain their existing company scale, so it is highly likely that domestic restructuring will take place in order to survive. Additionally, if hydrogen and electricity cannot be procured at competitive prices, then there is a risk scenario in which imported materials will increase to a certain extent. Policy support will also be an essential issue in order to overcome these barriers/challenges and to maintain the steel industry's competitiveness

Note 1: *Tsukurikomi* is a Japanese term for the process of incorporating material quality and processing techniques during the manufacturing process to achieve a desired result.
Note 2: *Suriawase* is a Japanese term for the process of coordination, fine-tuning, and precision integration between OEMs and suppliers to achieve a desired result.

Steel companies must consider and select the optimal plan for survival in anticipation of changes in industrial structure

Changes in External Environment

- Population decline
  Export difficulties
- Structural changes in automobile industry
  (local production for local consumption, electrification, gigacasting)
- Realizing carbon neutrality

Changes in Industrial Structure

- Decreased domestic crude steel production due to decreased domestic demand and export difficulties (**impact on quantity**)
- Lowered barriers to overseas general-purpose products due to decreased *suriawase* opportunities and diluted effectiveness (**impact on quality**)

Strengths

- *Tsukurikomi* and *suriawase*
- Vehicle body/ component design proposal know-how

Implementation of CPS (real x virtual)

Contributes to time/cost reductions and measures to address labor shortages
Value of remaining *tsukurikomi/suriawase* becomes more apparent

- ✓ Although the importance of the remaining *tsukurikomi and suriawase* will increase, the effects of and opportunities for *tsukurikomi* and *suriawase* are decreasing (electrical steel sheets and ultra high tensile strength steel)
- ✓ Tactics to compete only with high value-added products are no longer feasible, and the basic strategy should be to compete in the volume zone, which will become the cash cow

Winning Strategies (combining these is also an option)

1. Secure global volume and aim to become one of the global steel majors
2. Lead domestic restructuring to secure volume in Japan, while collaborating with overseas companies for regional expansion
3. Earn profits in non-steel businesses by handling aluminum, engineering, and downstream businesses

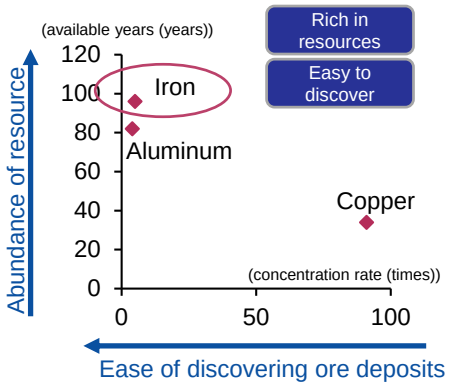
Source: Compiled by Mizuho Bank Industry Research Department

Although steel remains an important industry, it is facing major changes in the external environment

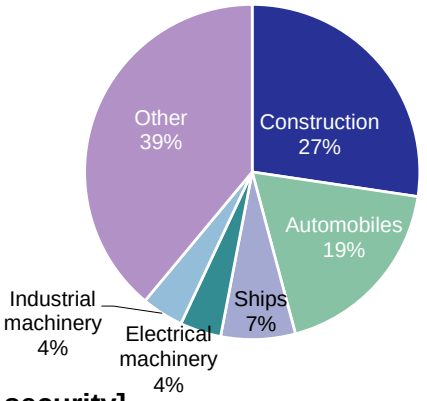
- Steel, which can be procured at a low cost, is used for a variety of purposes, including as a structural material, and plays an important role in security. Steel will continue to be an essential industry for manufacturing in Japan
- However, in addition to a declining population, the domestic steel industry is confronted with changes in the external environment, such as changes in the automobile industry (local production for local consumption, electrification, intelligence, and gigacasting)

Steel remains an important industry of Japanese industry

[Available at a low cost]



[Used in various industries]



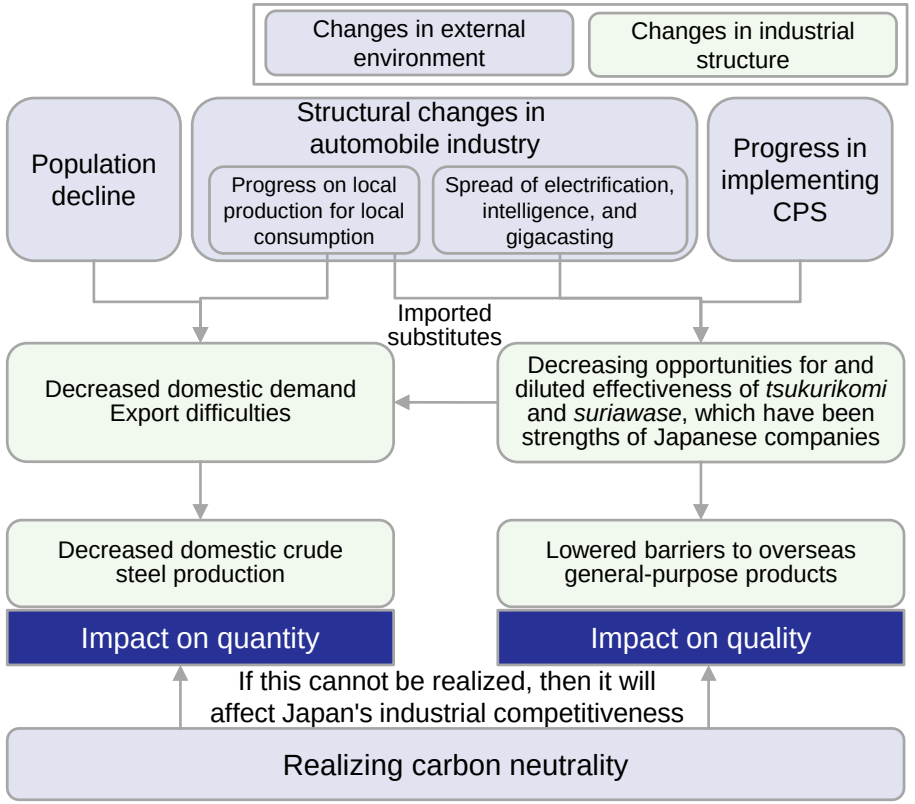
[Important materials for Japan's security]

11 specified important items (Cabinet Office)	Antibacterial preparations	Fertilizer	Permanent magnets	Machine tools and industrial robots	Aircraft parts
Semi-conductors	Storage batteries	Information/ communication networks	Flammable natural gas	Important ores and minerals	Ship parts

Steel remains an essential industry for manufacturing in Japan

Note 1: Pie chart only shows ordinary steel
Note 2: ■ indicates parts and materials that use steel
Source: Compiled by Mizuho Bank Industry Research Department based on materials from JOGMEC, the Japan Iron and Steel Federation, and the Cabinet Office

Changes in the external environment facing the domestic steel industry, and their impacts



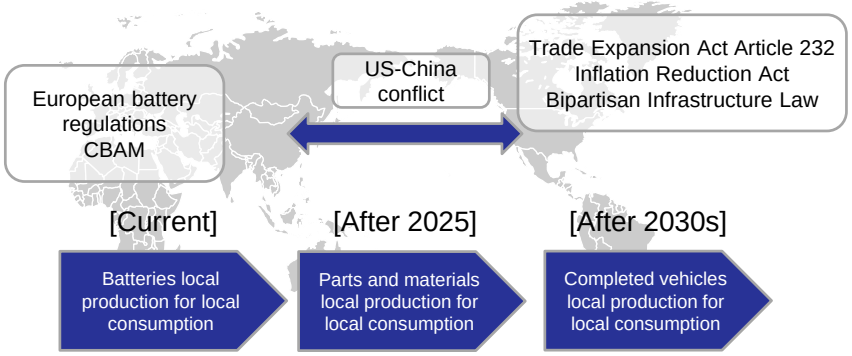
Source: Compiled by Mizuho Bank Industry Research Department

Impact on volume: Decreased domestic crude steel production

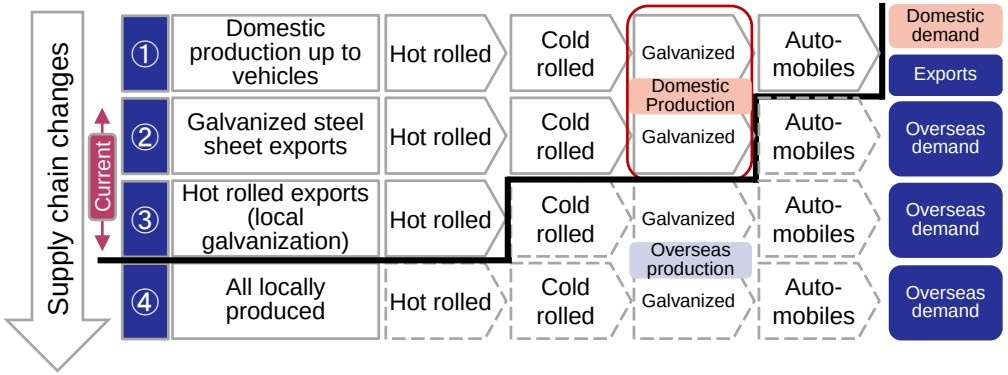
- In the automobile industry, in the medium term it is expected that, as the shift to electrification continues, for completed vehicle manufacturing there will be progress in local production for local consumption and in local procurement. In the past, exports of galvanized steel sheets have decreased and switched to local supply chains
- Domestic crude steel production for 2050 is assumed to be 50 to 67 million tons. Assuming maximum progress in local production for local consumption, primarily for automobiles, and that domestic production will only satisfy domestic demand, then 50 million tons is estimated (zero steel exports)

Structural changes in automobile industry (3): Progress on local production for local consumption

[Progress in local production for local consumption]

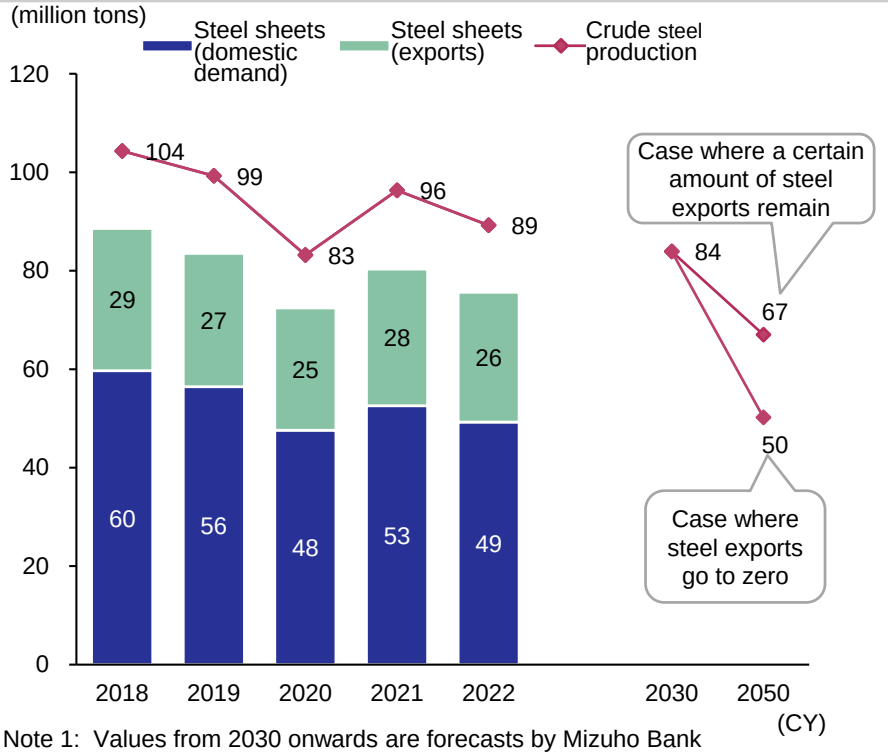


[Example of supply chain changes for galvanized steel sheets]



Source: Compiled by Mizuho Bank Industry Research Department

Domestic steel production forecast

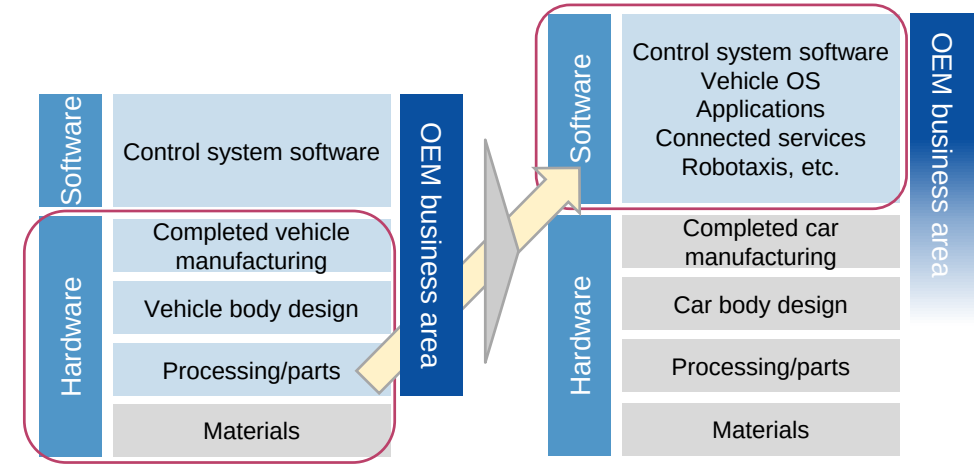


Note 1: Values from 2030 onwards are forecasts by Mizuho Bank
Note 2: If no exports remain, then imports will accordingly be switched to domestic production
Source: Compiled by Mizuho Bank Industry Research Department based on materials from the Japan Iron and Steel Federation

Impact on quality: Lowered barriers to overseas general-purpose products

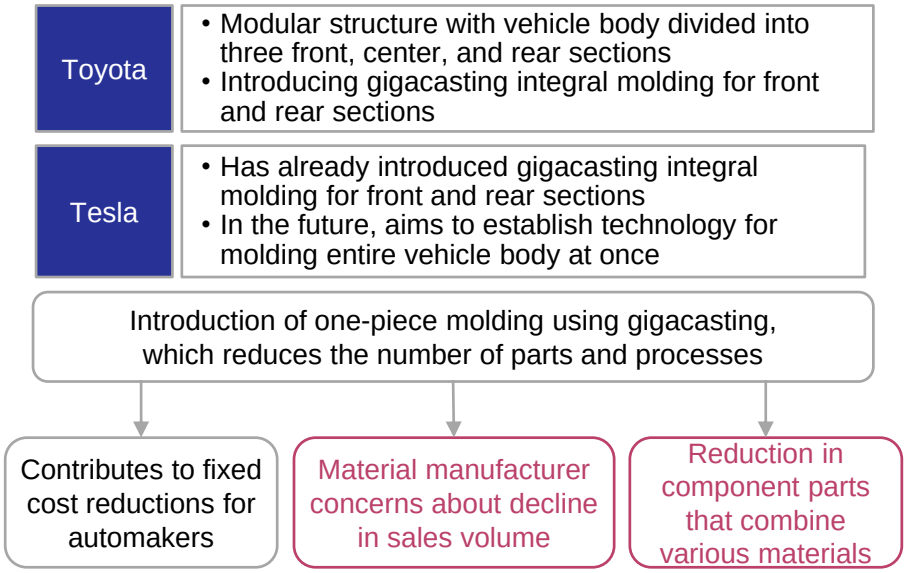
- With the progress in automobile electrification and intelligence, there is a possibility that opportunities for *tsukurikomi* and *suriawase*, which have been strengths of Japanese companies, will decrease and that their effects will become diluted
  - Concerns that the sources of added value in automobiles will shift from hardware to software, and that the importance of materials will become diluted
  - Concerns that the number of parts and processes will be reduced as gigacasting spreads

Structural changes in automobile industry (2): Progress in electrification and intelligence



There are concerns that the sources of added value will shift from hardware to software, and that the importance of materials will become diluted

Structural changes in automobile industry (3): Spread of gigacasting



Possibility that opportunities for *tsukurikomi* and *suriawase*, which have been strengths of Japanese companies, will decrease and that their effects will become diluted

Note 1: The "completed vehicle OEM business area" includes the business areas of affiliated suppliers
Note 2: Tesla refers to gigacasting as "Giga Press"
Source: Compiled by Mizuho Bank Industry Research Department from various press articles

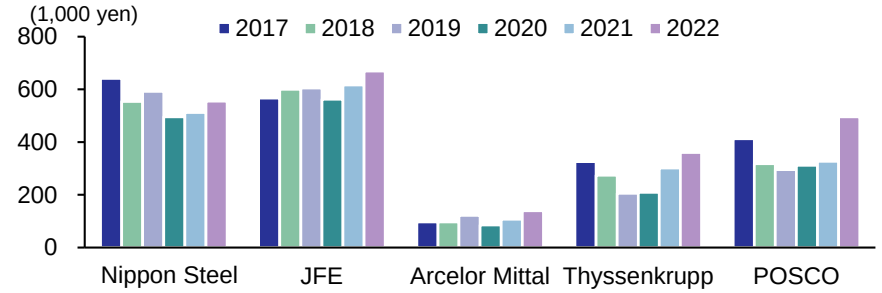
Tsukurikomi and *suriawase* are strengths of Japanese OEMs

- Japanese steel manufacturers' strengths are *tsukurikomi* and *suriawase* backed by an overwhelming level of R&D expenditures (Japanese steelmakers have the highest R&D expenditures per employee and highest ratio of R&D expenditures to sales)
- In order to get the first call from OEMS, Japanese steel manufacturers have a history of repeated *tsukurikomi* and *suriawase* not just to develop high value-added products and to reduce costs in manufacturing processes, but also to improving their know-how of design proposals for vehicle bodies and components

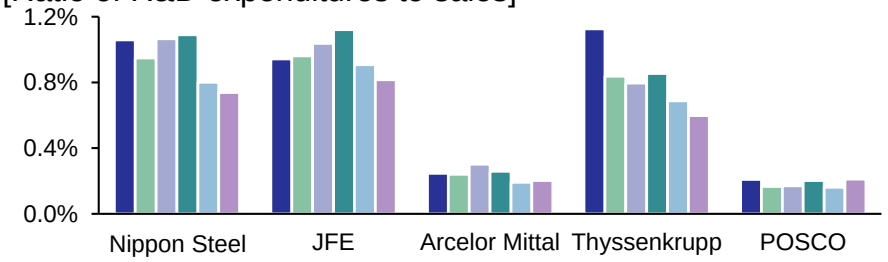
Comparison of steel companies' R&D expenditures per employee

A history of using abundant R&D expenditures to pursue high value-added product development and cost reductions in manufacturing processes

[R&D expenditures per employee]



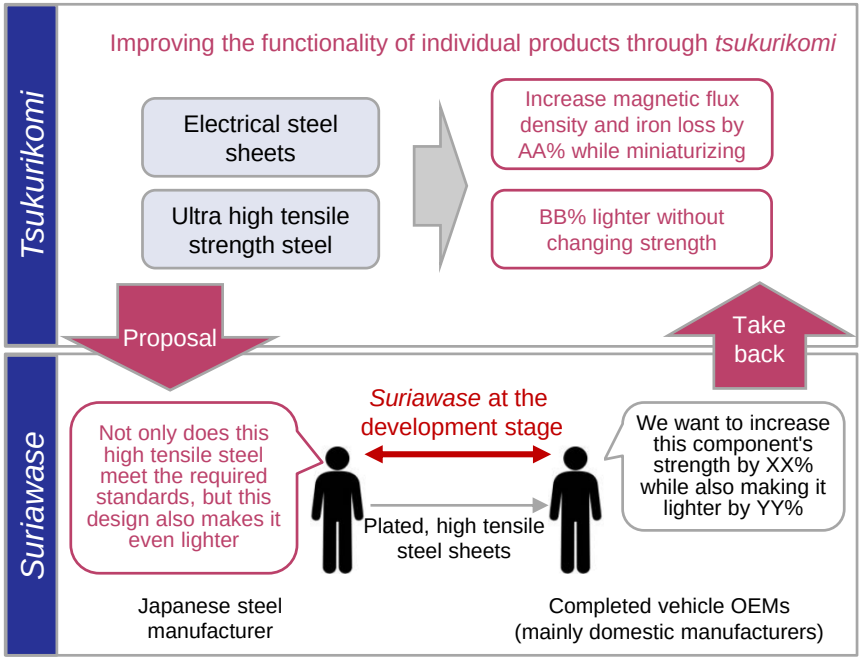
[Ratio of R&D expenditures to sales]



Source: Compiled by Mizuho Bank Industry Research Department based on SPEEDA and various companies' annual reports

Japanese companies excel at *tsukurikomi* and *suriawase*

A history of repeated trial and error to get the first call from OEMs

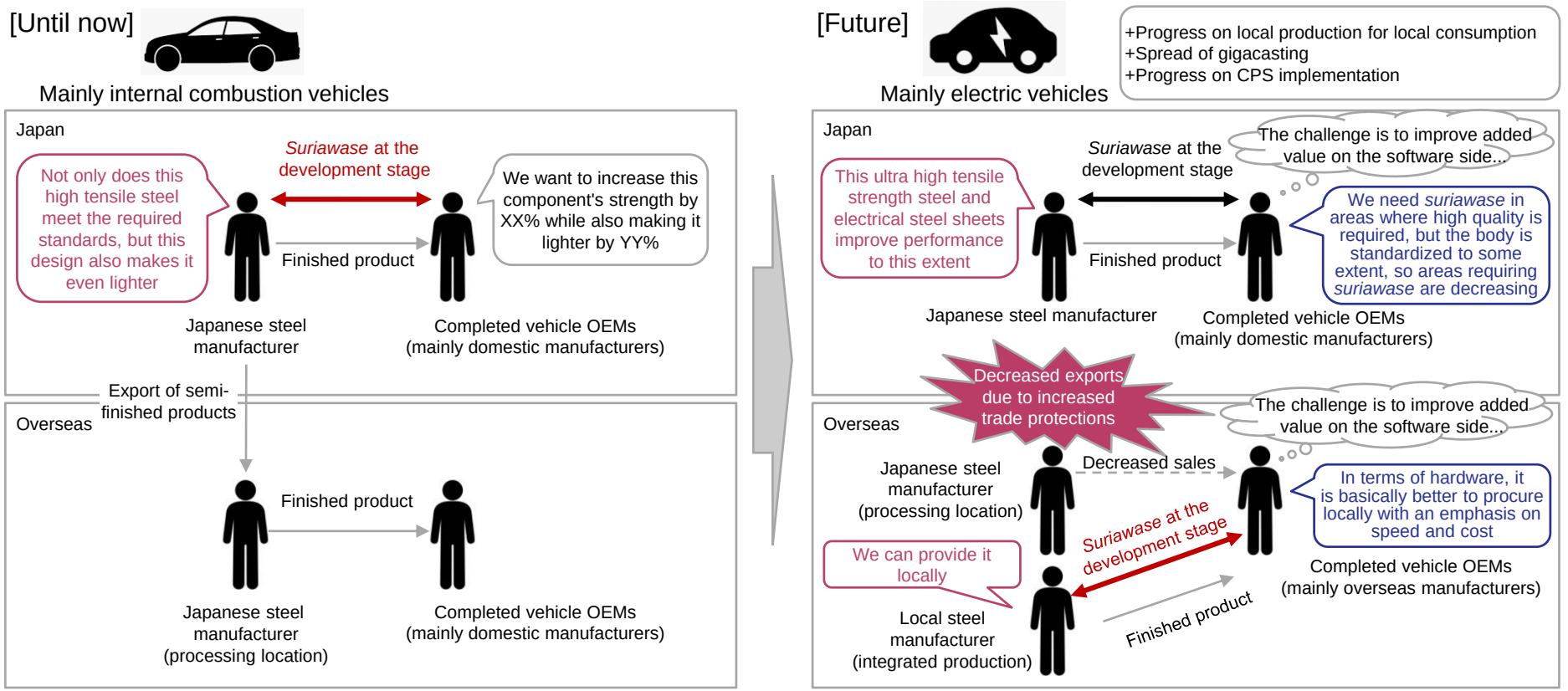


Source: Compiled by Mizuho Bank Industry Research Department

Changes in industrial structure may make it difficult to maintain Japan's strengths

- Until now (mainly for internal combustion vehicles), Japanese steel manufacturers have cultivated their ability to make proposals through long-standing relationships with completed vehicle OEMs via *suriawase* at the development stage
- In the future, as electric vehicles become more widespread, the barriers between Japanese steel manufacturers and general-purpose products from overseas will be lowered as vehicle bodies become standardized to a certain extent. It is also assumed that there will be a decrease in areas where *suriawase* is required (hardware will basically shift to an emphasis on speed and cost)
  - In addition, it is assumed that overseas there will be more local procurement and production, including *suriawase*

Possibility that opportunities for *tsukurikomi* and *suriawase* will decrease and that their effects will become diluted (Mizuho hypothesis)



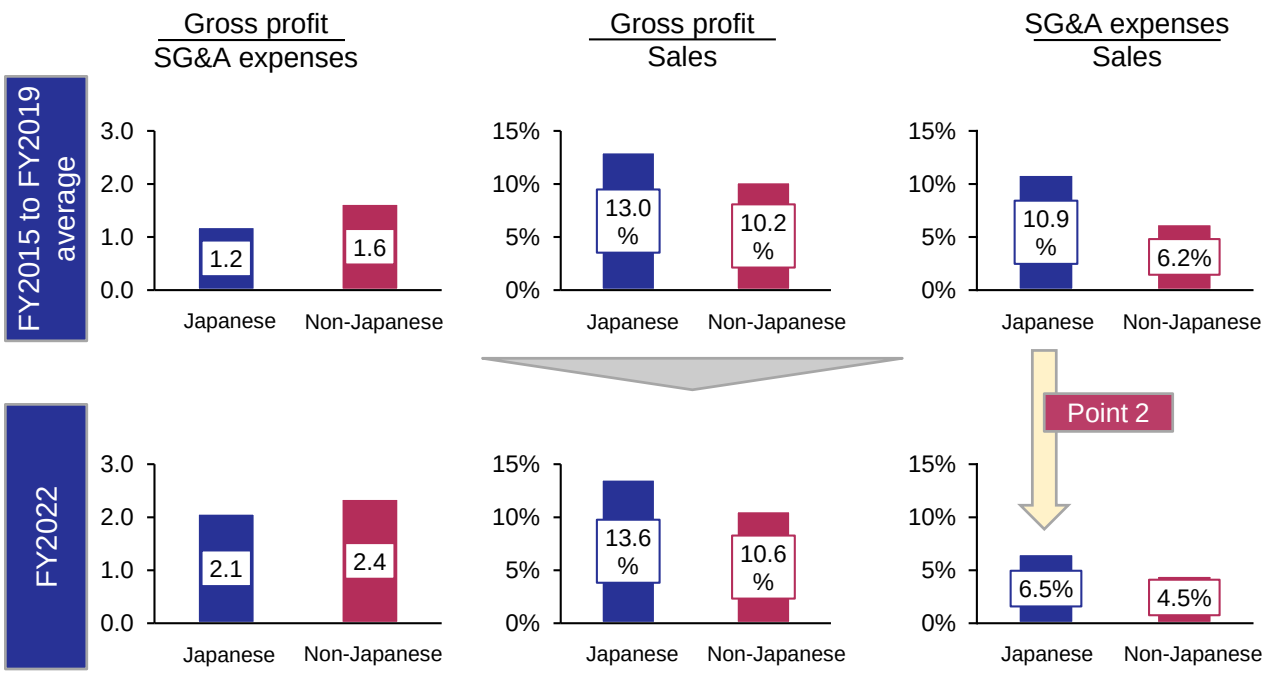
Source: Compiled by Mizuho Bank Industry Research Department

From the perspective of non-Japanese OEMs, Japan's strengths may be excessive quality and service

- Although Japanese companies have an advantage in terms of gross profit ratio, they lag non-Japanese companies in terms of SG&A expense ratio, and, as a result, their operating ROI (sales productivity) is inferior to that of non-Japanese companies

Comparison of operating ROI between Japanese and non-Japanese steel manufacturers

Operating ROI = Gross profit ratio + SG&A expense ratio



Point 1

Although Japanese companies have higher gross profit ratio, their operating ROI is lower than that of non-Japanese companies as a result of their SG&A expense ratio (however, due to the effects of improved sales prices, the gap with non-Japanese companies has improved in the most recent period)

Point 1

Due to Japanese OEM's advanced demands, Japanese steel manufacturers' SG&A expense ratio is currently higher than that of non-Japanese steel manufacturers

In light of structural changes in the automobile industry, expanding sales channels not just to Japanese OEMs, but also to non-Japanese OEMs, is a necessary strategy

From the perspective of non-Japanese OEMs, Japan's *tsukurikomi* and *suriawase* may be excessive quality and service

Point 2

It is speculated that one of the reasons for improved sales prices is that the value of *tsukurikomi* and *suriawase* was being properly understood

With a worldview of decreased *tsukurikomi* and *suriawase* opportunities and diluted effectiveness, there is a risk that continuing the same level of quality and service as before will result in a return to previous levels

Note: Each index is calculated for three Japanese blast furnace companies and three non-Japanese blast furnace companies (ArcelorMittal, Thyssenkrupp, Posco) using two patterns for 2015-2019 average values (pre-COVID-19) and for 2022 (most recent period)

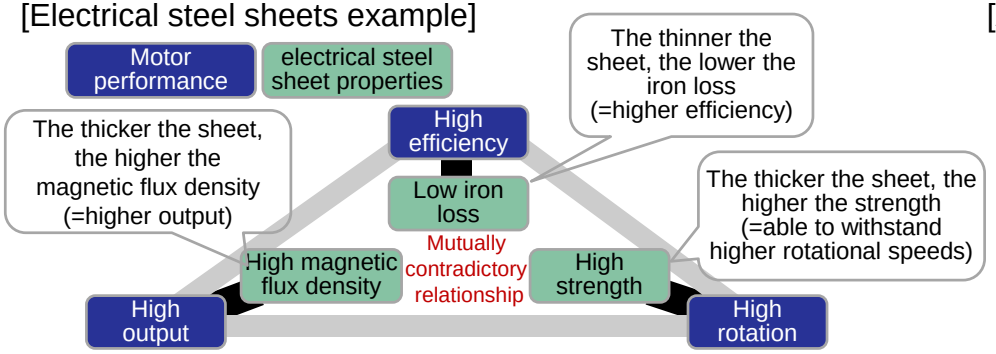
Source: Compiled by Mizuho Bank Industry Research Department based on SPEEDA

Will *tsukurikomi* and *suriawase* opportunities and effects disappear?

- As electric vehicles become more widespread, other new functions will be required, so *tsukurikomi* and *suriawase* will not disappear, but it is assumed that as vehicle bodies become more standardized to a certain extent, there will be a decrease in areas that require *tsukurikomi* and *suriawase* (i.e. high value-added products). That being said, it is also assumed that the importance of these remaining areas that require *tsukurikomi* and *suriawase* will increase
- On the other hand, the scale of the remaining *tsukurikomi* and *suriawase* is small to begin with and requires constant R&D. As such, a strategy of only competing with high value-added products is not feasible, and basic route will be to compete in the volume zone, which is the cash cow

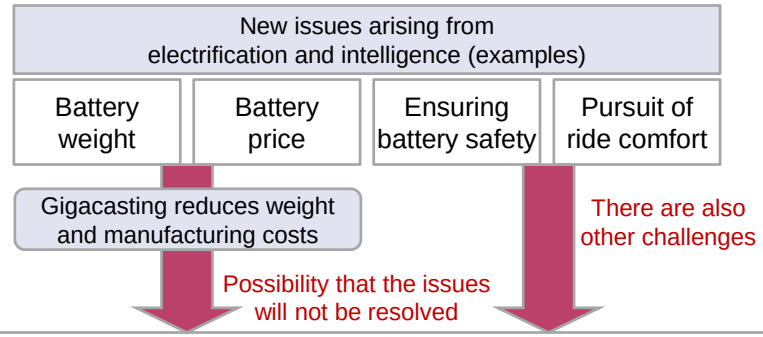
It is assumed that *tsukurikomi* and *suriawase* will remain, and that their effects will be emphasized in the future

[Electrical steel sheets example]



- ✓ Motors are the heart of a BEV, and, with the required motor characteristics vary depending on vehicle model, it is believed that the importance of *tsukurikomi* and *suriawase* for electrical steel sheets will continue to grow
- ✓ The technology for accurately forming thin still plates originates from automobile steel sheet processing technologies (technology transfer from steel manufacturers to processing manufacturers), but in China, where there has been a rapid shift to BEVs, there is a possibility that the technologies are not being sufficiently passed on

[Automotive steel sheets (ultra high tensile strength) example]



- ✓ Because gigacasting molds in a single piece, it is difficult to control the thickness of each part. This means there is no choice but to use thicker sheets overall, and there is a possibility that the full weight reduction benefits cannot be obtained (aluminum is also expensive in terms of price)
- ✓ As more and more emphasis is placed on improving the "experiential value" of automobiles, it is assumed that there will be increasing pursuit of new features such as sound proofing, vibration proofing, and a comfortable ride
- ✓ In order to address these challenges, it is important to know how to process inexpensive and highly rigid steel (by making full use of technologies that Japan has an advantage in, such as cold pressing)

However, volume itself is limited

Continuous R&D is necessary to supply high value-added products in small quantities, so focus should be volume zone business that will become a cash cow

Source: Compiled by Mizuho Bank Industry Research Department based on the Nippon Steel website and various press articles

Reference: Nippon Steel aims to balance quantity and quality while accelerating global expansion

- In its medium- to long-term management plan, Nippon Steel announced that it will accelerate its global expansion while striving to achieve both quantity and quality
- Nippon Steel's policy is to aim for a global crude steel production capacity of 100 million tons and to become the world's second-largest steel company, while also increasing the weight of high value-added products and building an earnings structure that is unaffected by the external environment
  - This suggests that the direction Nippon Steel is aiming for cannot be achieved solely in terms of quality or quantity

Nippon Steel's medium- to long-term management plan and specific initiatives

	[Major direction]	[Specific initiatives]
Quantity	✓ Reach a global crude steel capacity of 100 million tons ✓ Ensure high added value via an integrated steel manufacturing system for areas where demand is definitely expected and for areas where the company can utilize its technological and product strengths	• Acquired two electric furnace companies in Thailand • Announced a joint venture in India for construction of two new blast furnaces • Announced a joint venture in the US for a new electric furnace, and announced acquisition of U.S. Steel
Quality	✓ Increase sophistication of order structure ✓ Increase ratio of high value-added products (such as electrical steel sheets, high-tensile steel, and seamless steel pipes) while also seeking an optimal production system that balances with quantity ✓ Optimize direct contract sales margins	• Shut down four blast furnaces (Kohura, Wakayama, Kure) and planning the shutdown of three Kashima blast furnaces • Announced a new line of electrical steel sheets in Japan (JPY 123.0 billion)

Rebuilding the domestic steel business, deepening and expanding the overseas business, and building an earnings structure that is unaffected by the external environment

Become the world's No. 1 steel manufacture with comprehensive capabilities

Source: Compiled by Mizuho Bank Industry Research Department based on Nippon Steel press release materials

Global crude steel production ranking

Rank	Company name	Crude steel production volume
1	Baowu Steel Group (China)	131.8
2	Arcelor Mittal (Luxembourg)	68.9
3	Ansteel Group (China)	55.7
4	Nippon Steel (Japan)	44.4
5	Jiangsu Shagang Group (China)	41.5
6	Hesteel Group (China)	41.0
7	POSCO (South Korea)	38.6
8	Beijing Jianlong Heavy Industry Group (China)	36.6
9	Shougang Group (China)	33.8
10	Tata Steel (India)	30.2
⋮	⋮	⋮
14	JFE Steel (Japan)	26.2
⋮	⋮	⋮
57	Kobe Steel (Japan)	6.3

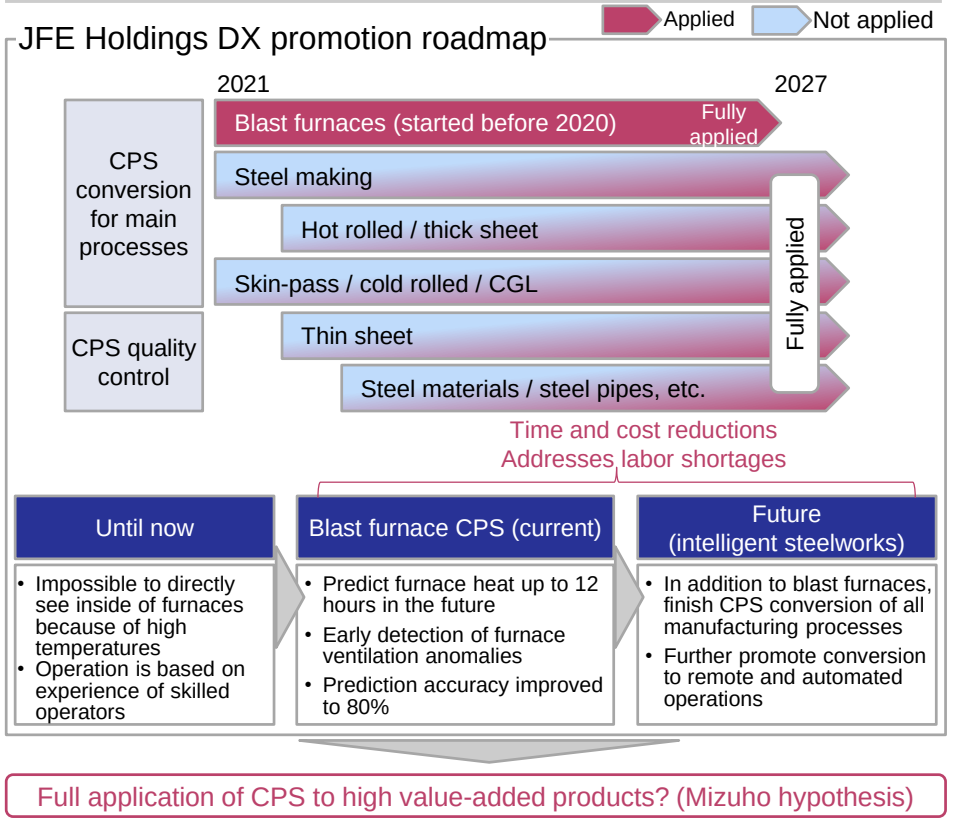
Current production capacity of 66 million tons

Source: Compiled by Mizuho Bank Industry Research Department based on World Steel Association materials

As CPS implementations progress, they may be a factor in lowering the barriers for high value-added products

- Blast furnace manufacturers have already introduced CPS to their blast furnaces, and are using it to predict furnace heat and for the early detection of ventilation anomalies in the furnaces. In the future, CPS will be introduced to all manufacturing processes in addition to blast furnaces, which will contribute to time and cost reductions and will address labor shortages
- Due to the development of various digital technologies, including CPS, new steel manufacturers with advanced technological capabilities have emerged, and steel manufacturing know-how is being concentrated in steel manufacturing engineering companies. This may also be a factor for why barriers to high value-added products, which were the strength of domestic steel manufacturers, are being lowered

Case study of CPS implementation by a blast furnace manufacturer (JFE Holdings)

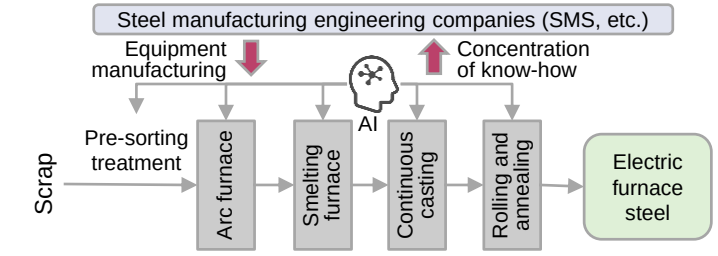


Source: Compiled by Mizuho Bank Industry Research Department based on JFE Holdings' DX REPORT

Rise of new steel manufacturers and concentration of know-how in steel manufacturing engineering companies

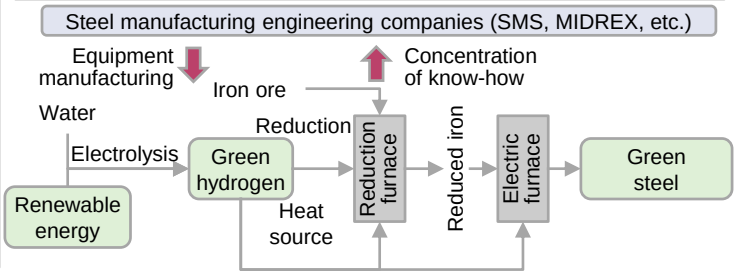
Big River Steel 2014 (US)

- ✓ Supports optimal electric furnace operation by letting AI learn from data collected by numerous sensors
- ✓ Additionally, is trying to produce non-oriented electrical steel sheets in an electric furnace and will start operating a production line in October 2023



H2 Green Steel 2020 (Sweden)

- ✓ In 2025 will begin direct hydrogen reduction steel making utilizing green energy and green hydrogen, aiming to produce 5 million tons of green steel by 2030 (fastest in Europe)
- ✓ Implementing equipment control technologies that utilize digital technology

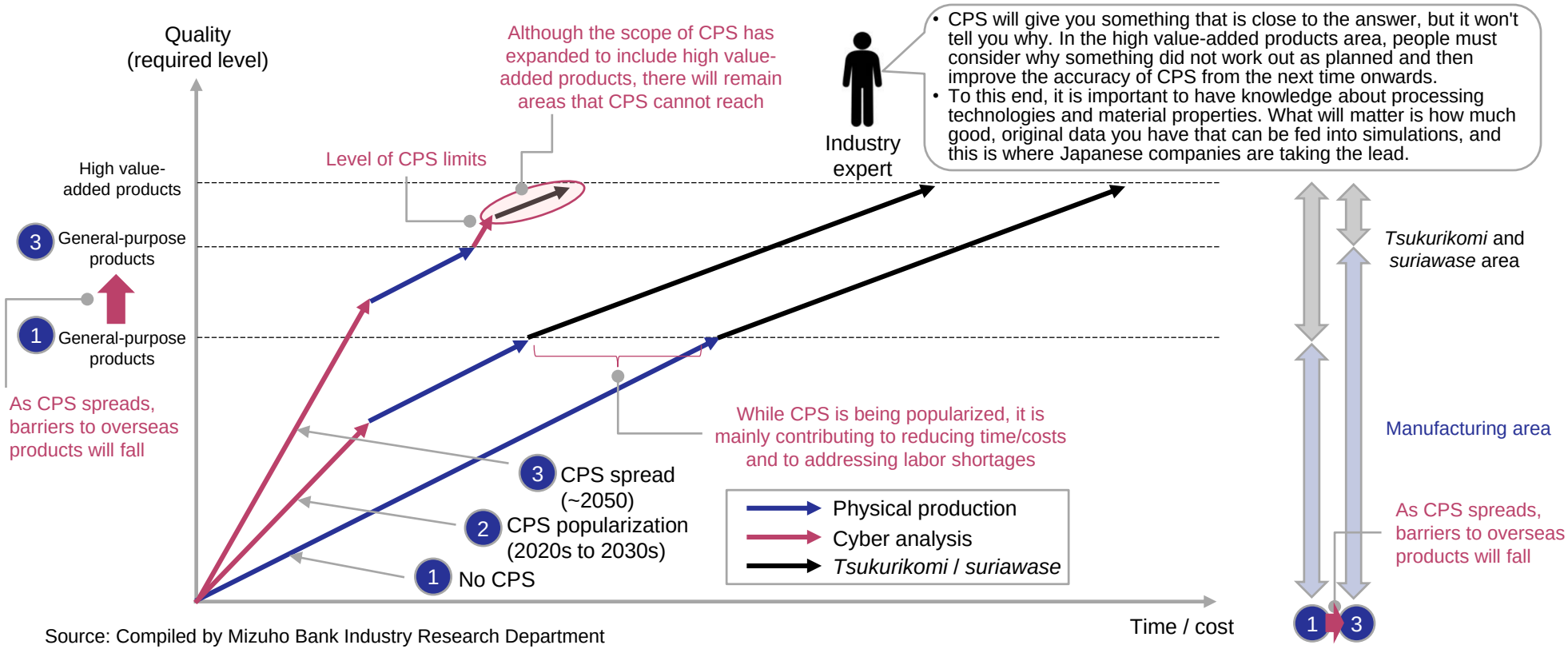


Source: Compiled by Mizuho Bank Industry Research Department based on each company's website

[Mizuho hypothesis] Although there will be progress in implementing CPS, there are some areas CPS cannot reach

- While CPS is being popularized, such as right now, it is mainly contributing to reducing time/costs and to addressing labor shortages. But, in a world where CPS has become widespread and commonplace, it is expected that CPS will be adopted to a certain extent even in the high value-added products area
- However, even if CPS implementation makes even further strides, it is thought that there will still be some areas that CPS cannot reach – that is, the *tsukurikomi* and *suriawase* areas that require human input. When also competing in the high value-added area, it will be important for Japanese companies to maximize their strengths, such as advanced processing techniques and knowledge of material properties, as well as to have high-quality analysis data that can be fed into CPS

Illustration of the effects of introducing CPS (Mizuho hypothesis)



Source: Compiled by Mizuho Bank Industry Research Department

Each company must find winning strategies according to their focus areas

- With major environmental changes in the steel and automotive industries on the horizon, there appear to be three possible winning strategies

Pattern for and illustration of winning strategies for Japanese steel manufacturers (Mizuho hypothesis)

Environment changes

- ✓ An important theme is the realization of an overseas growth strategy that takes into consideration the shrinking medium- to long-term domestic steel demand as well as the increasing difficulty of exports (due to progress in local production for local consumption)
- ✓ On the other hand, with the structural changes in the automobile industry and the progress in implementing CPS, it is possible that there will be a decrease in (but not a disappearance of) opportunities for and effects of Japanese companies' traditional strengths of *tsukurikomi* and *suriawase*

Points to consider to survive

- ✓ First, companies should thoroughly purse an expansion of quantity in their own focus areas (e.g. global/domestic, ordinary steel/special steel)
- ✓ After securing quantity, companies should incorporate the *tsukurikomi* and *suriawase* (quality) areas that remain even after the overseas shift to BEVs and the structural changes in the automobile industry (e.g. high-quality steel such as electrical steel sheets and ultra high tensile strength steel)

Winning strategies for Japanese companies

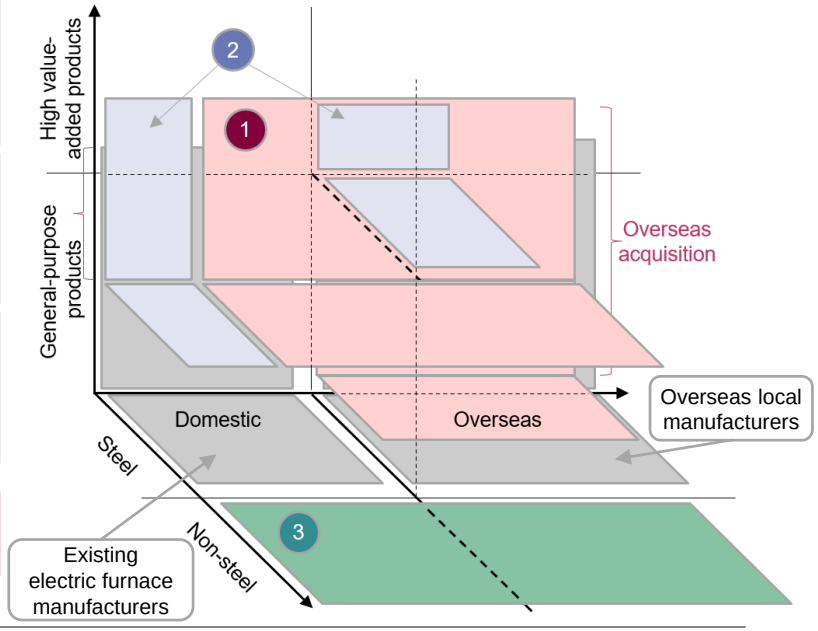
1
- ✓ By securing "quantity" on a global basis and becoming an industry insider in each region, companies can respond to the industry trend of local production for local consumption. Strengthen quality based on the cash obtained through this process
- ✓ Aim to become one of the global steel majors by acquiring overseas steel manufacturers

2
- ✓ Secure quantity in the domestic market and maintain a firm position.
- ✓ To do so, lead restructuring of domestic companies. Using the cash and technologies obtained domestically, partner with overseas local steel companies and support their growth in quality by providing technologies as a technology company

3
- ✓ Become involved with non-steel materials (aluminum and rare metals, etc.), engineering, and downstream businesses (components and vehicle body manufacturing), and make money in non-steel businesses by leveraging the strengths of *tsukurikomi* and *suriawase*, which were cultivated in the steel business

- ✓ Companies must also be aware of strategies to avoid regional and quality conflicts/overlaps with Chinese companies, which have an advantage in terms of quantity
- ✓ Companies must find a direction before the 2030s, when changes in industrial structure are expected to become apparent

[Directionality of winning strategies]



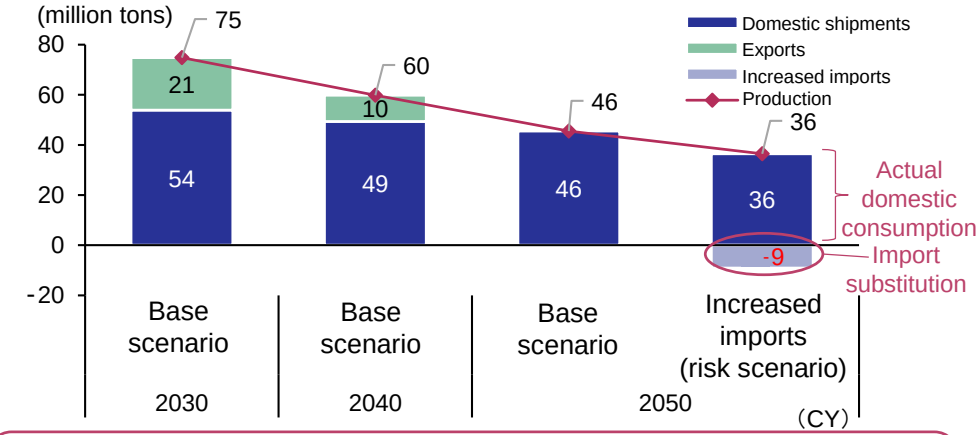
Source: Compiled by Mizuho Bank Industry Research Department

Supplement: Domestic restructuring and policy support are essential for domestic steel companies to find winning strategies

There are further downside risks than the base scenario (= a future to be avoided)

Base scenario	✓ 2050 crude steel production: 50 million tons~ (steel production: 46 million tons~) ✓ Domestic production will be matched to domestic demand, and each company will search for winning strategies while maintaining the domestic steel industry's business base ✓ However, some steel manufacturers will be unable to maintain the existing scale of their companies
Risk scenario (a future to be avoided)	✓ An inability to procure hydrogen and electricity at competitive prices will make it difficult to domestically produce steel via blast furnace hydrogen reduction, direct hydrogen reduction, or in large electric furnaces, which will result in a certain amount of increase in imported materials ✓ The number of steel manufacturers unable to maintain the existing scale of their companies will further increase

[Forecast for actual domestic steel consumption (steel base)]

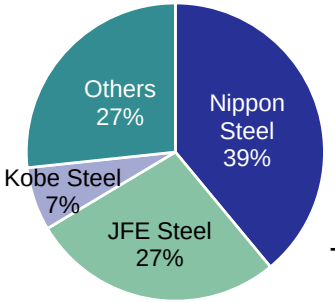


- ✓ Steel is an indispensable industry for Japan's economic security, and it is necessary to maintain a certain level of domestic production capacity
- ✓ Even in the risk scenario case, in order to maintain the domestic steel industry it is assumed that a minimum level will be maintained at all costs via "domestic production for the amount actually consumed domestically"

Source: Compiled by Mizuho Bank Industry Research Department
Source: Compiled by Mizuho Bank Industry Research Department based on materials from the Japan Iron and Steel Federation

Assumed crude steel production volume from steel manufacturers under base and risk scenarios

[Estimated future crude steel production volumes]



(million tons)

	2022	2050 (estimate)	
		Base	Risk
Nippon Steel	34	20	16
JFE Steel	24	14	11
Kobe Steel	6	3	2
Others	24	13	11
Crude steel production volume	88	50	40

- ✓ Although there are multiple winning strategies depending on each company's area of focus, under both the base and risk scenarios it is highly likely that some steel l manufacturers will be unable to maintain their existing corporate scale, which will lead to domestic restructuring to ensure survival
- ✓ In the risk scenario, it is also necessary to consider the possibility that steelmakers will be consolidated into a single domestic company in order to maintain the domestic steel industry

Challenges/barriers to avoid the risk scenario

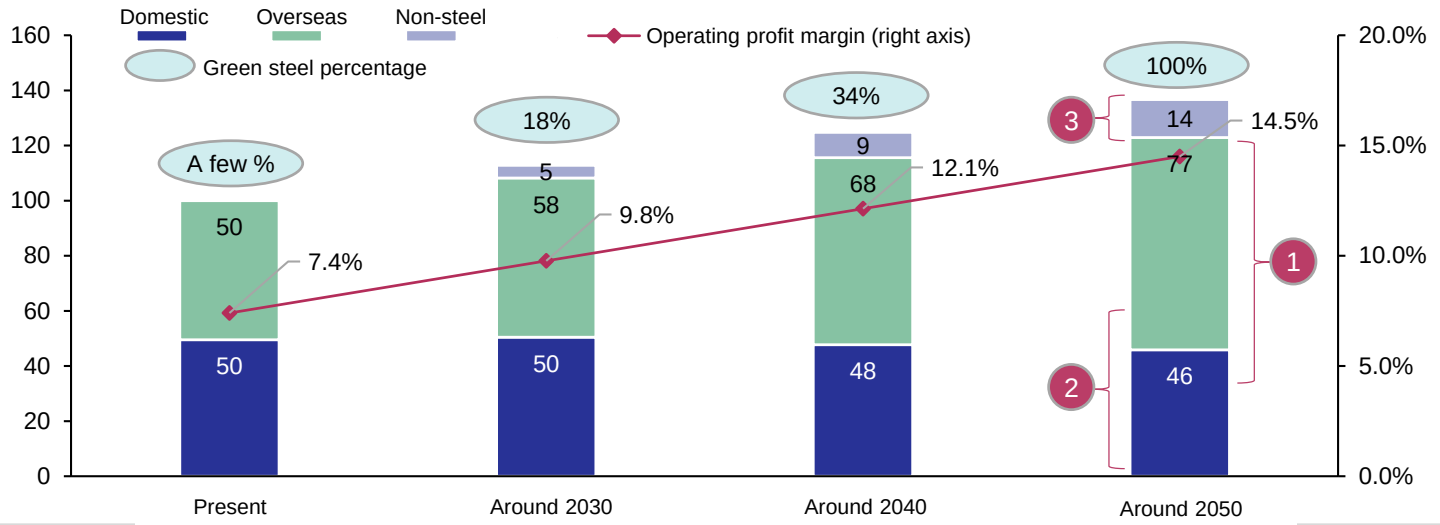
- ✓ Policy support is essential for the steel industry to remain competitive

Procuring raw materials and fuel at appropriate prices	Supporting hydrogen producers
Preventing an excessive influx of imported materials	Imposing import duties
Promoting restructuring	Consideration of antitrust laws
Developing a market for green steel	Price difference support for manufacturers

etc.

Note: Future crude steel production volumes are estimated based on maintaining existing market share
Source: Compiled by Mizuho Bank Industry Research Department based on materials from the Japan Iron and Steel Federation

[Mizuho hypothesis] Trends in sales and operating profit margin in the steel industry



	Present	Around 2030	Around 2040	Around 2050
Comment	• Domestic: Gradually decreasing in line with domestic demand • Overseas: Currently, steel exports (or export of semi-finished products and local processing into finished products) is the major source. It is assumed that exports will gradually decline and that integrated overseas production will become the mainstream • Non-steel: Existing non-steel businesses are excluded (hereafter, only increases are shown)	• Domestic: Start of restructuring. The initial restructuring/culling will be with special steel/regular steel • Overseas: Steel exports have declined, and integrated production is making progress in some overseas countries. India and Southeast Asia will have integrated production models from upper processes (general-purpose products), while in North America the export model will partially continue with a focus on high-grade steel • Non-steel: Engineering/aluminum, and high alloys/magnetic materials, etc.	• Domestic: Further restructuring/culling underway. Possible restructuring amongst blast furnace manufacturers • Overseas: Steel exports continue to decline. North America adopts the integrated production model. India and Southeast Asia will also see an increase in the proportion of high-grade steel • Non-steel: Domestic restructuring underway, but some companies will aim to grow non-steel primary businesses through corporate divestitures, etc.	• Domestic: Zero steel exports, and, from the perspective of national resilience and security, domestic production will be maintained at all costs • Overseas: India and Southeast Asia increase their proportion of high-grade steel • Profitability is expected to gradually increase based on (1) overseas full-scale integrated production, (2) increased price competitiveness due to domestic restructuring, and (3) expansion into other growth areas
Technological premise	• Assumes that progress basically follows the METI roadmap • Blast furnaces: 65; electric furnaces: 24	• Large-scale electric furnaces • COURSE50 (blast furnace hydrogen reduction) • Blast furnaces: 48; C50: 8; electric furnaces: 30	• Super COURSE50, CR blast furnaces (hydrogen reduction blast furnaces) • Direct hydrogen reduction • Blast furnaces: 28; C50: 10; electric furnaces: 29	• Achieving carbon neutrality by combining with CCUS • C50: 3; SC50: 9; hydrogen reduction: 7; electric furnaces: 31

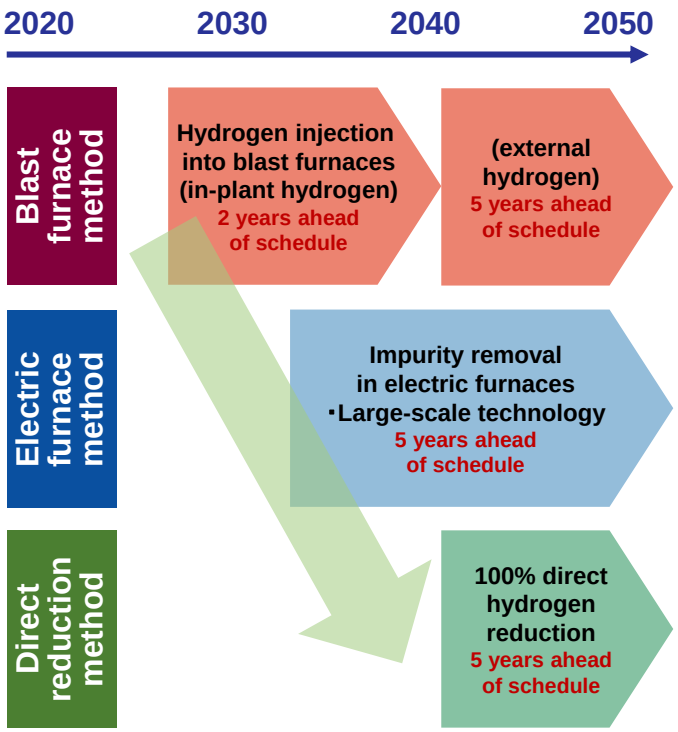
Note 1: Sales are shown as an index, with 100 representing current sales for the domestic steel industry (approx. JPY 15 trillion in monetary terms)
Note 2: The green steel percentage is based on an assumption that the composition for non-thermal power (incl. CCS thermal power) source composition will be 50% in 2030, 75% in 2040, and 100% in 2050.
Source: Compiled by Mizuho Bank Industry Research Department

Appendix.

Initiatives towards Carbon Neutrality

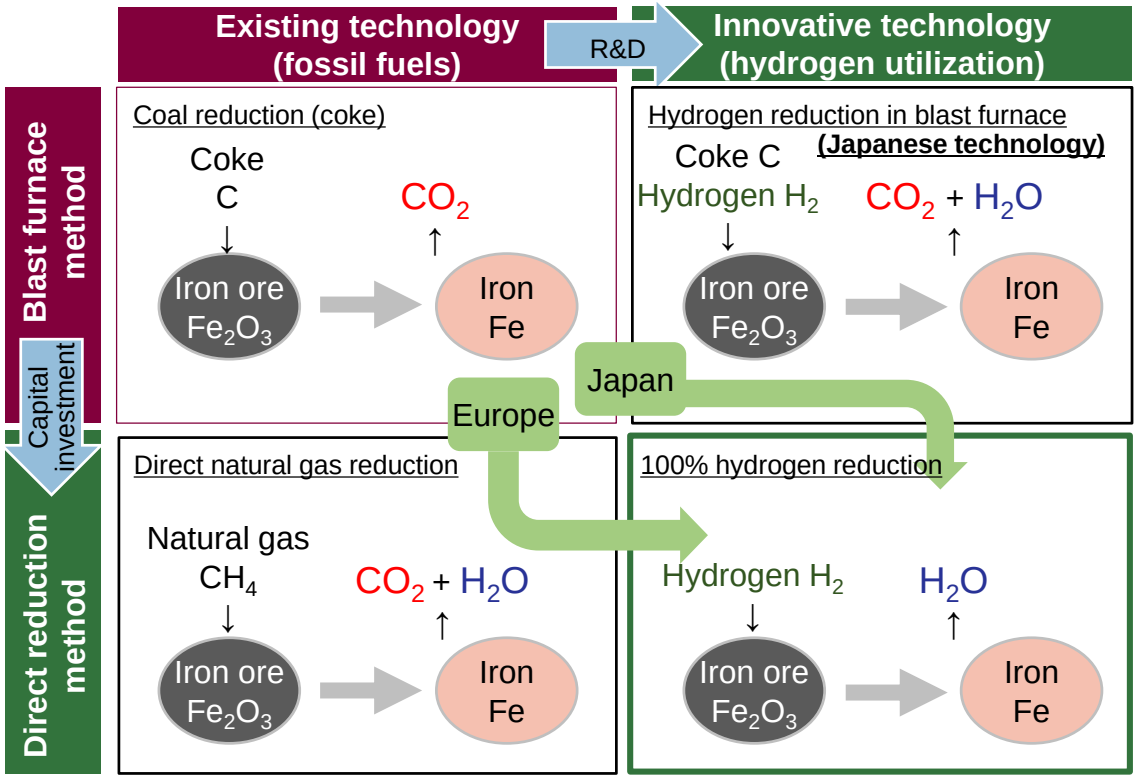
- Achieving carbon neutrality by 2050 will be an extremely difficult challenge for the Japanese steel industry, where blast furnace processes account for 80% of production
- In October 2021, the Ministry of Economy, Trade and Industry formulated a technology roadmap for making the steel industry carbon neutral. The plan calls for Japan's unique and innovative technologies, which reduce CO_2 emissions by injecting hydrogen into existing blast furnaces, to be put into actual production from around 2030
  - The Japanese steel industry's approach to carbon neutrality differs from that of the European steel industry, which has launched a series of direct iron reduction plants that utilize natural gas

Japan's technology roadmap (excerpt)



Source: Compiled by Mizuho Bank Industry Research Department based on materials from the Ministry of Economy, Trade and Industry

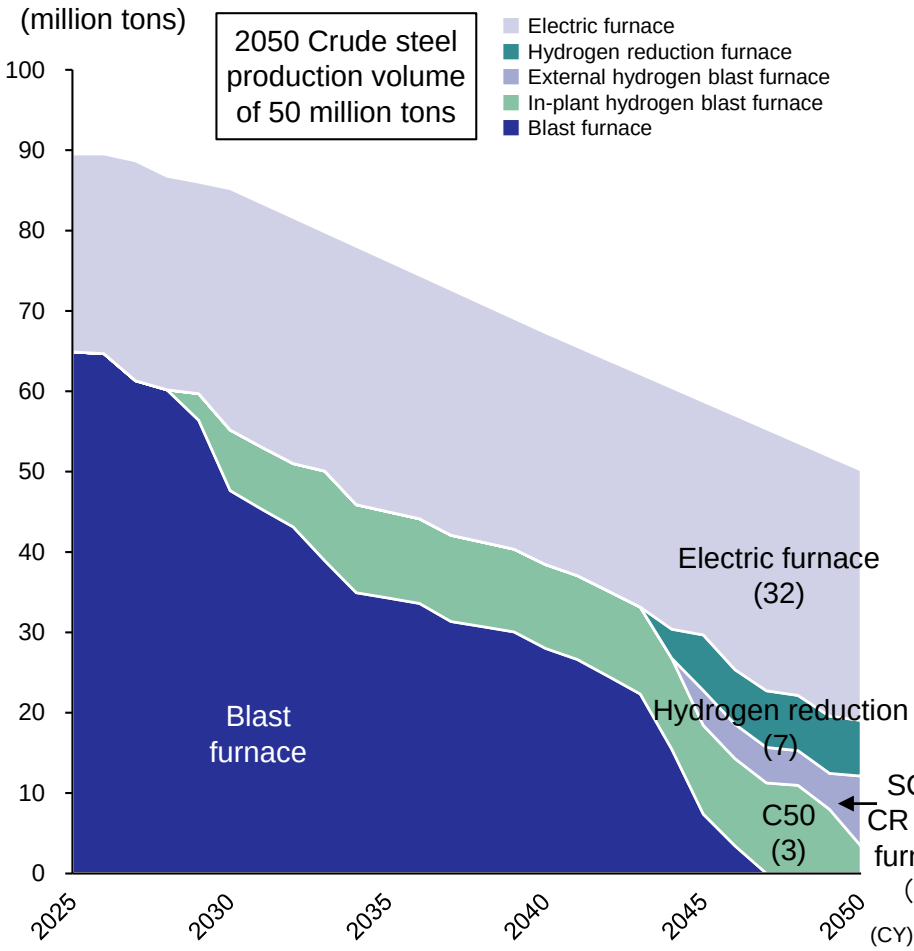
Japanese and European companies' approaches to 100% hydrogen reduction



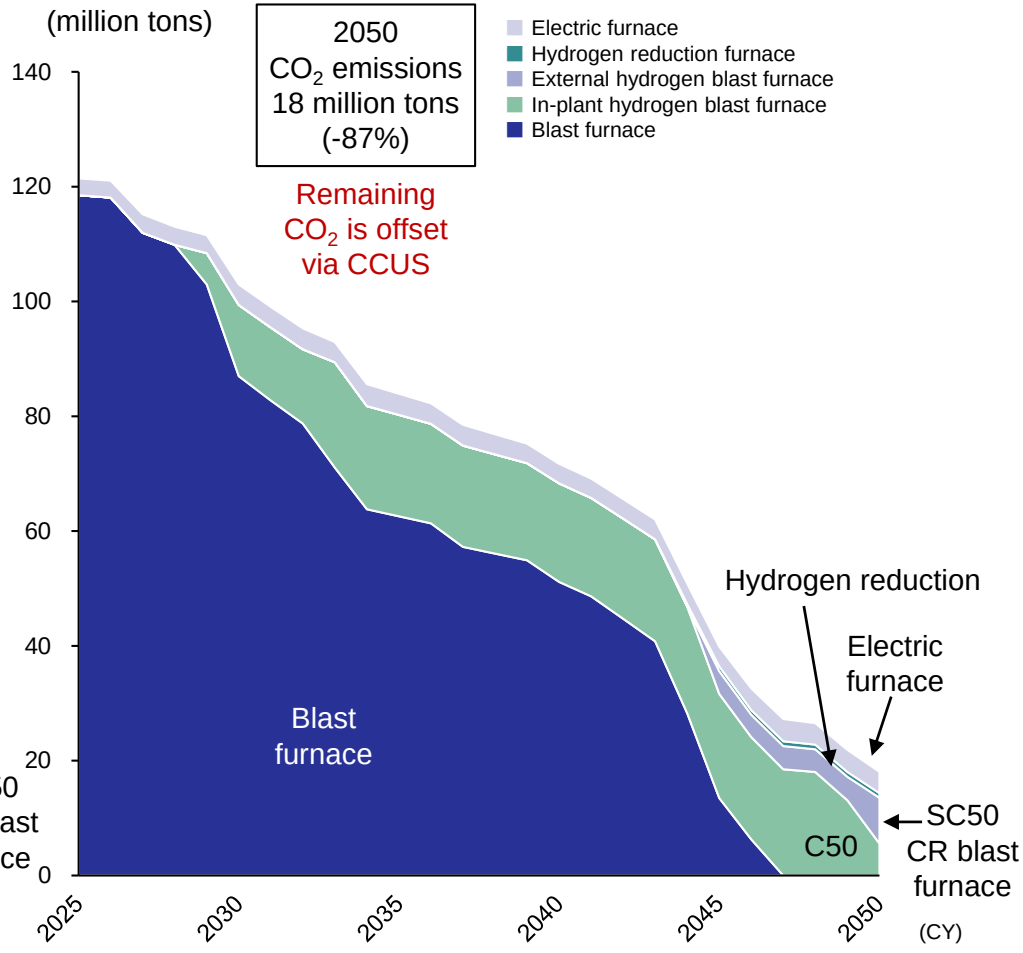
Source: Compiled by Mizuho Bank Industry Research Department based on materials from the Ministry of Economy, Trade and Industry

Pathway to 2050

Simulation of crude steel production volume by furnace type



Simulation of CO_2 emissions



Note 1: All figures are estimates by Mizuho Bank Industry Research Department. When blast furnaces are updated every 20 years, they are either deactivated or replaced with new technologies that have already been developed. Steelworks located adjacent to petrochemical complexes or CN ports will transition to COURSE50, Super COURSE50, or hydrogen reduction, while others will transition to electric furnaces. However, considering the price of hydrogen, in Japan the maximum number of hydrogen reduction furnaces was limited to two.
Note 2: CO2 emissions reduction rates are compared to 2019 figures
Source: Compiled by Mizuho Bank Industry Research Department

Japan announces it is accelerating the development of hydrogen reduction technology

- The three blast furnace companies formed the Hydrogen Steelmaking Consortium in June 2022, and plan to share information and develop/utilize CN technology from across the companies, but European companies are ahead in some areas, such as direct hydrogen reduction technology (Chinese and Korean companies are also moving forward with technological development)
- In response to this situation, in September 2023 at the Industrial Structure Council there was a proposal for a revised roadmap (moving technology development forward by 2 to 5 years) and for an increase in the amount allocated to the GI fund (+JPY 256.4 billion). In order for the domestic steel industry to not lose its competitiveness, they will have to continue to develop technology at a speed comparable to what is being done by overseas companies, and to also increase the cost competitiveness of hydrogen and electricity procurement

Formation of a cross-company consortium for decarbonization

Hydrogen Steelmaking Consortium (launched June 2022)

Nippon Steel / SFE Steel / Kobe Steel / JRCM

GI fund
JPY 193.5 billion to 449.9 billion (increase)

Information sharing / joint technology development and use

		[Technology development details]	[Furnace used]	[Roadmap revision proposal (overview)]	[Budget revision proposal]
Blast furnace hydrogen reduction	(1)	Development of hydrogen reduction technology utilizing in-plant hydrogen (COURSE50)	Blast furnace + converter	Actual demonstration tests to begin in second half of 2025 Aiming to implement the technology **by 2028**	JPY 46.3 billion (+29.6 billion)
	(2)	Development of low-carbon technology utilizing external hydrogen and blast furnace exhaust gases (Super COURSE50/CR Blast Furnace)	Blast furnace + converter	Develop elemental technology by 2025 and begin testing in small-scale test blast furnace Aiming to implement the technology **by 2040**	JPY 238.6 billion (+117.2 billion)
Direct hydrogen reduction	(3)	Development of direct hydrogen reduction technology	Hydrogen reduction furnace + large-scale electric furnace	Develop elemental technology by 2025 and begin testing in small-scale test blast furnace Aiming to implement the technology **by 2040**	JPY 114.1 billion (+79.6 billion)
	(4)	Development of impurity removal technology for electric furnaces utilizing direct reduction iron	(Hydrogen reduction furnace) + large-scale electric furnace	Develop elemental technology by 2025 and begin testing in small-scale electric furnace Aiming to implement the technology **by 2030**	JPY 30.6 billion (+7.0 billion)
	(5)	Development of hydrogen reduction technology utilizing an electric melting furnace (smelter)	(Hydrogen reduction furnace) + smelter + converter	Medium-scale electric furnace tests by around 2026 Aiming to implement the technology **by 2030**	JPY 2.30 billion **(newly added)**

Note 1: "JRCM" is an abbreviation for Japan Research and Development Center for Metals
Note 2: "CR blast furnace" is an abbreviation for carbon recycling blast furnace
Note 3: Kobe Steel is not participating in (3)
Note 4: (4) and (5) are considering the import of hydrogen reduced iron from overseas
Source: Compiled by Mizuho Bank Industry Research Department based on materials from the Hydrogen Steelmaking Consortium and the Ministry of Economy, Trade and Industry

Examples of hydrogen reduction technology development by overseas companies

Europe / Arcelor Mittal

- ✓ Direct hydrogen reduction demonstration plant being built in Germany, with operations scheduled to begin by the end of 2025
- ✓ Also proceeding with construction of new DRI plants and electric furnaces, primarily in Germany and France

Europe / Thyssenkrupp

- ✓ Started H2Stahl project to develop both blast furnace hydrogen reduction and direct hydrogen reduction technologies
- ✓ Plans to construction a 1.2 million ton/year DRI plant by around 2025

China / Baowu Steel

- ✓ Bayi Iron & Steel began research on hydrogen reduction using a small blast furnace (scheduled to begin operations at the end of 2024)
- ✓ Decided to construct a 1 million ton/year DRI plant at Zhanjiang Iron & Steel (scheduled to begin operations at the end of 2024)

South Korea / POSCO

- ✓ Moving forward with the development of HyREX direct hydrogen reduction technology that utilizes their unique FINEX steelmaking technology

Source: Compiled by Mizuho Bank Industry Research Department based on various materials

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Mizuho Industry Research／75 2024(1)　Published March 1, 2024

Edited / issued by Industry Research Department Mizuho Bank, Ltd　1-3-3 Marunouchi, Chiyoda-ku, Tokyo　ird.info@mizuho-bk.co.jp