NIPPON STEEL

Carbon Neutral Vision of Nippon Steel

NET ZERO

NIPPON STEEL
Green Transformation
initiative

September 2nd, 2024

Clean Coal Day International Meeting

NIPPON STEEL CORPORATION

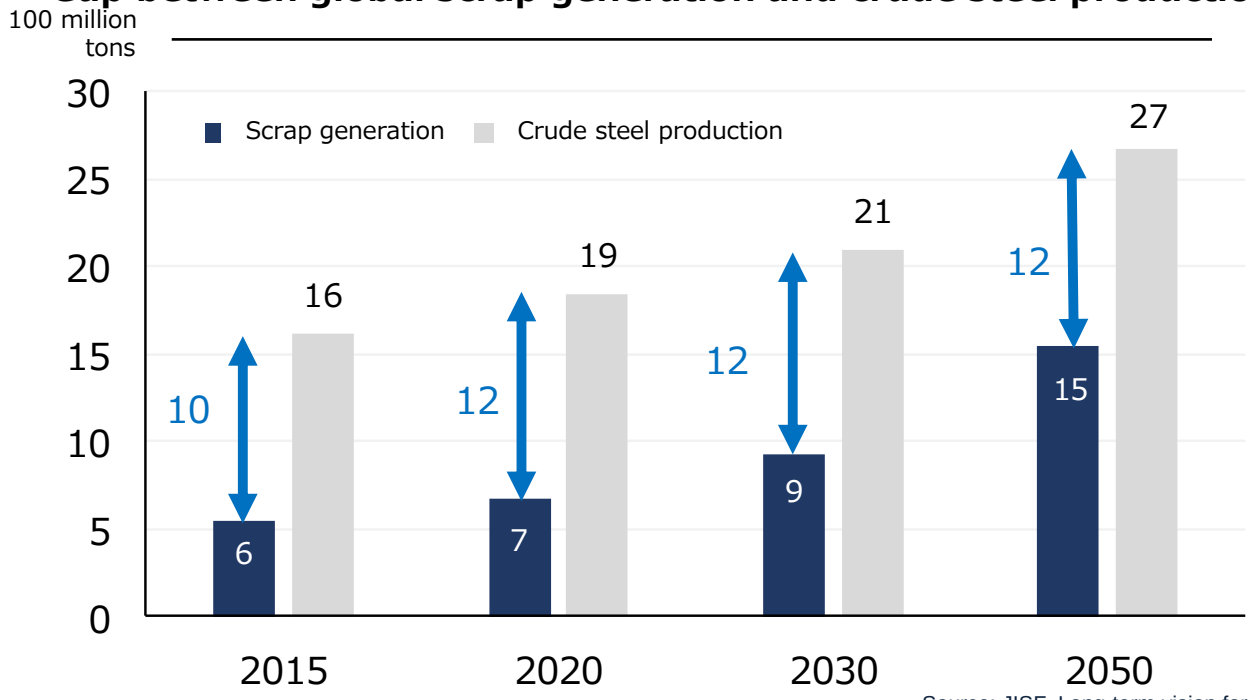
Ironmaking by iron ore reduction is necessary for the future

To make steel products, either iron ore (iron oxide) must be reduced or scrap (after reduction) must be recycled.

Scrap generation increases with steel stocks.

- However, even in 2050, global scrap generation is expected to remain at about 50% of crude steel production, and the iron ore reduction process will continue to be essential.

Gap between global scrap generation and crude steel production



Steelmaking by scrap recycling alone cannot meet the world's steel demand (This situation will be the same in 2050.)

From a volume perspective, it is essential to produce and use **iron ore-reduced steel**.

Source: JISF, Long-term vision for climate change mitigation: A challenge towards zero-carbon steel

Reduction is an essential process in extraction of Iron from its ores[3]

In nature, iron exists as oxides, iron ore. To produce steel products, oxygen must be removed (= reduced) from iron ore.

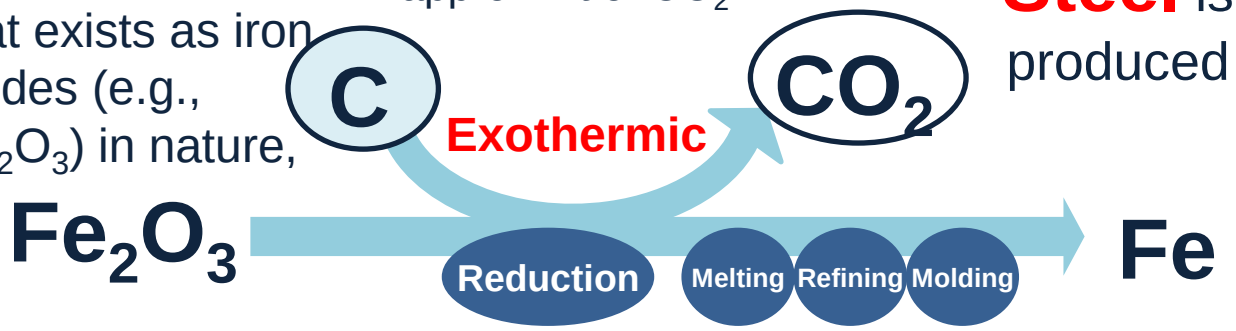
Reduction by carbon (coal)

- Mass productive
- Stable in proficiency
- Cost competitive

From **iron ore** that exists as iron oxides (e.g., Fe_2O_3) in nature,

1t of steelmaking emits approx. 2t of CO_2

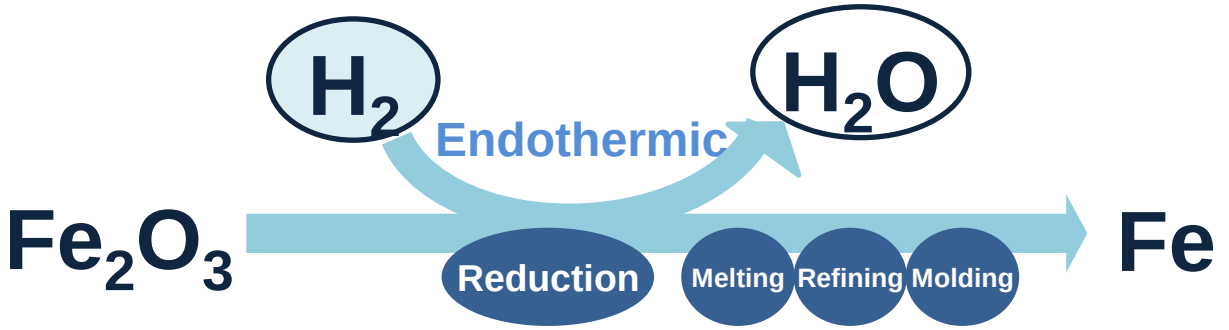
Steel is produced



Reduction by hydrogen

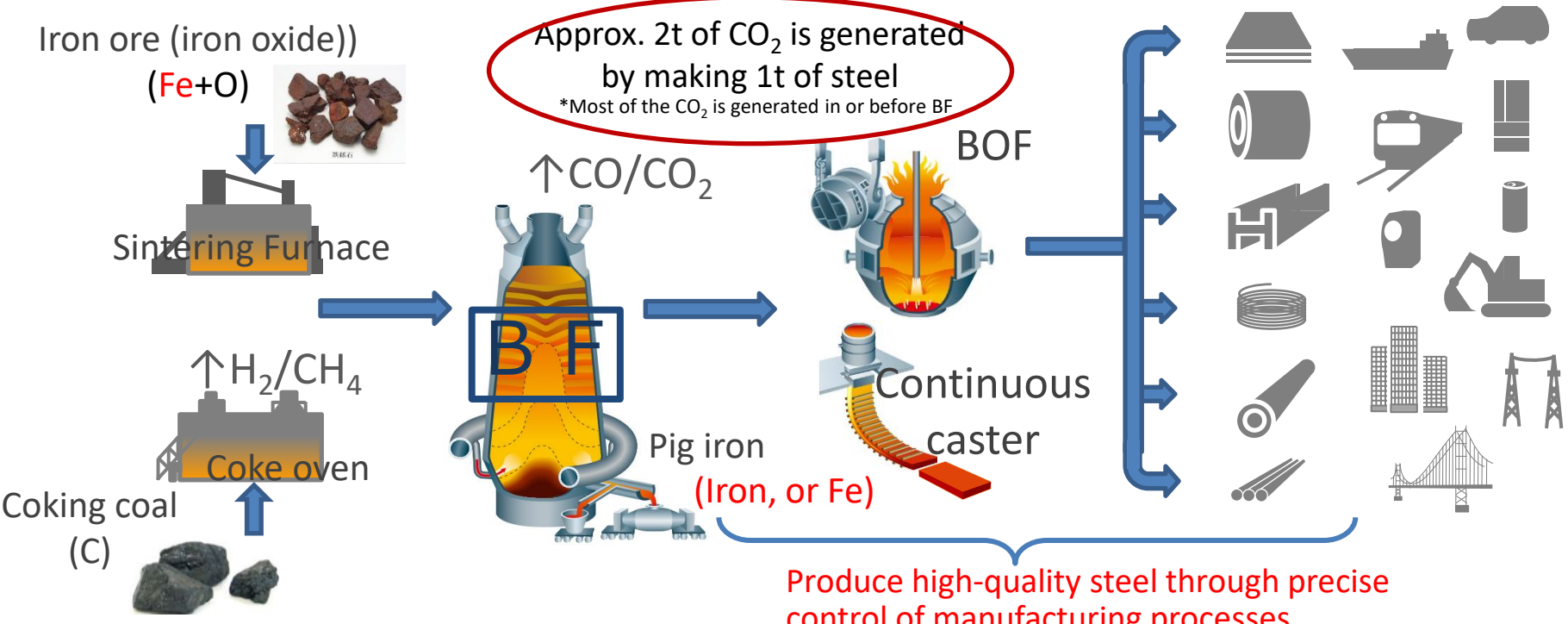
Challenge:

- CO_2–free process



Process for reducing iron ore : Blast Furnace(BF) Method Features

- Currently, BF method is the only process in which high-grade steel can be mass-produced from iron ore.
- Unlike many other manufacturing industries where respective products are processed in dedicated lines, in steel industry all products share the same upstream line and diverge into different product lines.
- BF method is extremely efficient system where the by-product gas generated in iron ore reduction and melting by coking coal can be reused as energy source (heat, electric power, etc.) for the integrated steel making processes



1) Iron ore, or iron oxide, is removed of oxygen (reduced) and turns into 1,500 ℃ molten iron

2) Molten iron is removed of impurities and solidified into semi-finished products with standardized sizes and shapes

3) Semi-finished products are processed into steel products with respective sizes, shapes, and features (through processes such as hot-rolling, annealing, galvanizing, etc.)

Carbon Neutral Vision 2050

Released in March 2021

<Aim to reduce CO_2 emissions by 30% by 2030 and achieve carbon neutrality by 2050>

Our 2030 target is ambitious compared to those of our global peers, and is feasibly aligned with the Japanese government's plan

Provision of high-performance steel products and solutions that contribute to reducing CO_2 emissions in society

- Reduce CO_2 emissions at the time of production and processing by customers
- Reduce CO_2 emissions at the time of use of our products by end customers

Decarbonization of steelmaking process for providing carbon neutral steel

- Reduce CO_2 emissions in customers' supply chains

By providing high-performance steel products and solutions, and by decarbonizing steelmaking process ahead of other countries, we are determined to provide carbon neutral steel to our customers (including approximately 6,000 companies in Japan) and support their international competitiveness. From September 2023, we will launch sales of NSCarbolex® Neutral, a steel product that is certified as reducing CO_2 emissions by a third-party organization.

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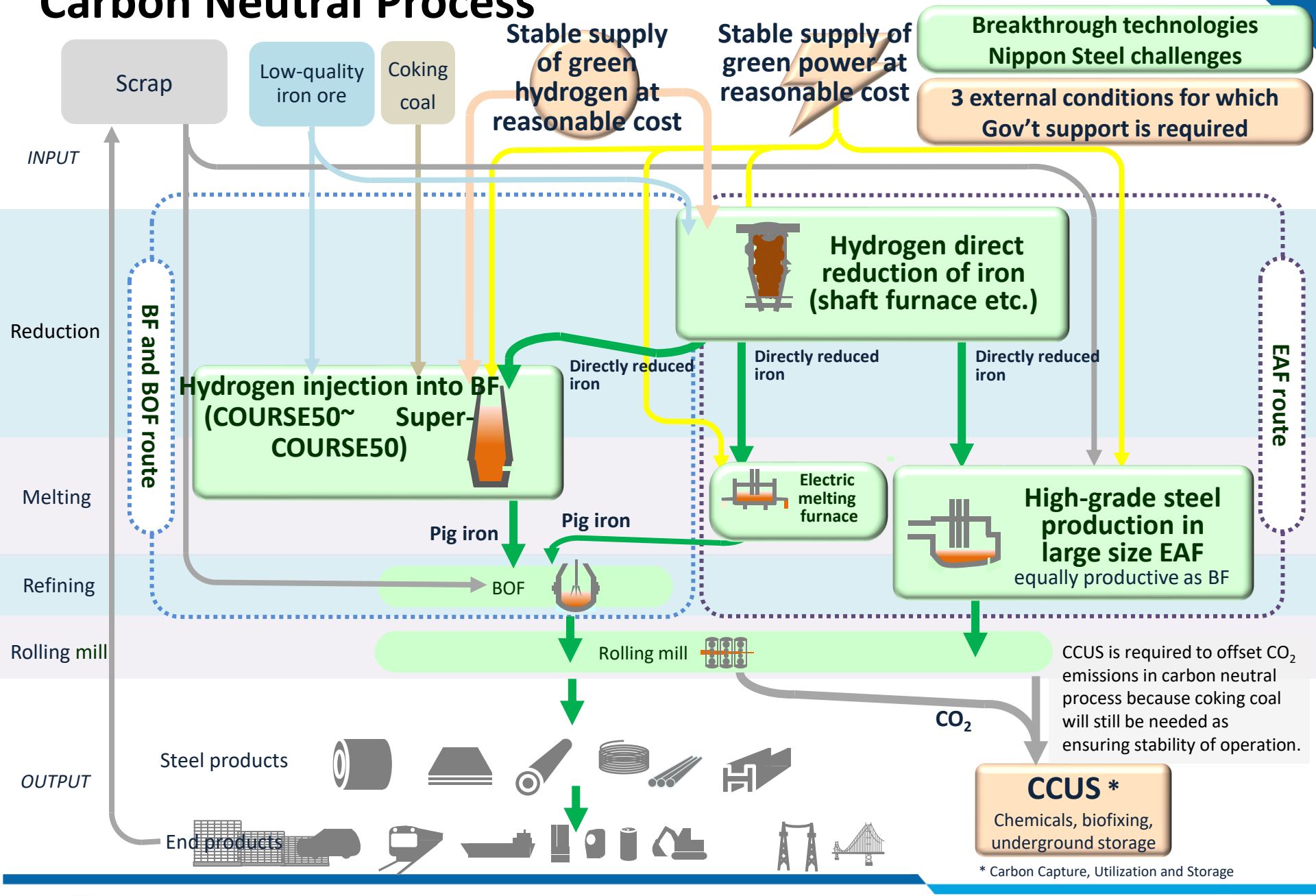
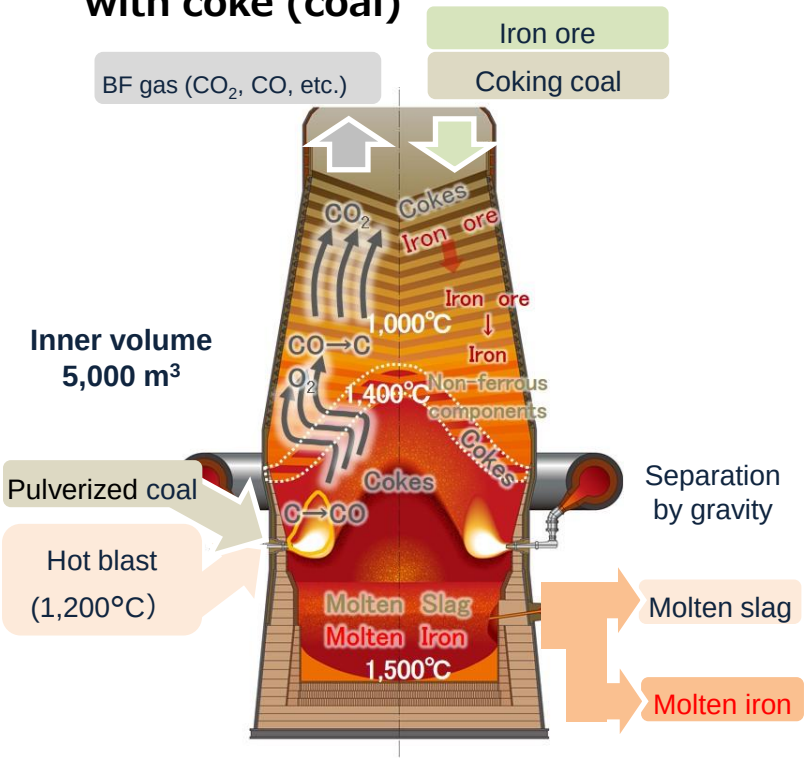
NIPPON STEEL Green Transformation initiative

Carbon Neutral Process



Challenges of Hydrogen Utilization in Blast Furnaces

1. Current blast furnace operation with coke (coal)



a) Reducing agent and Source of heat
b) Support of raw materials at high temperature, maintaining gas flow in the furnace

*Gas from blast furnace is utilized as an energy source.

2. Technical Challenges in Hydrogen Conversion

Reduction with carbon

$Fe + O \rightarrow Fe$ (C → CO_2) **Exothermic**

- Generating CO_2
- Due to the exothermic reaction,1) the reaction is sustained and 2) the iron is melted at high temperature, and the composition can be easily adjusted

Reduction with hydrogen

$Fe + O \rightarrow Fe$ (H_2 → H_2O) **Endothermic**

- Generating H_2O(steam)
- Due to the temperature drop in the furnace, 1) the reaction is not sustained and 2) produced iron does not melt

⇒Challenge:
Injection hydrogen at high temperature (with explosion risk)

Challenges of 100% hydrogen use in direct reduction

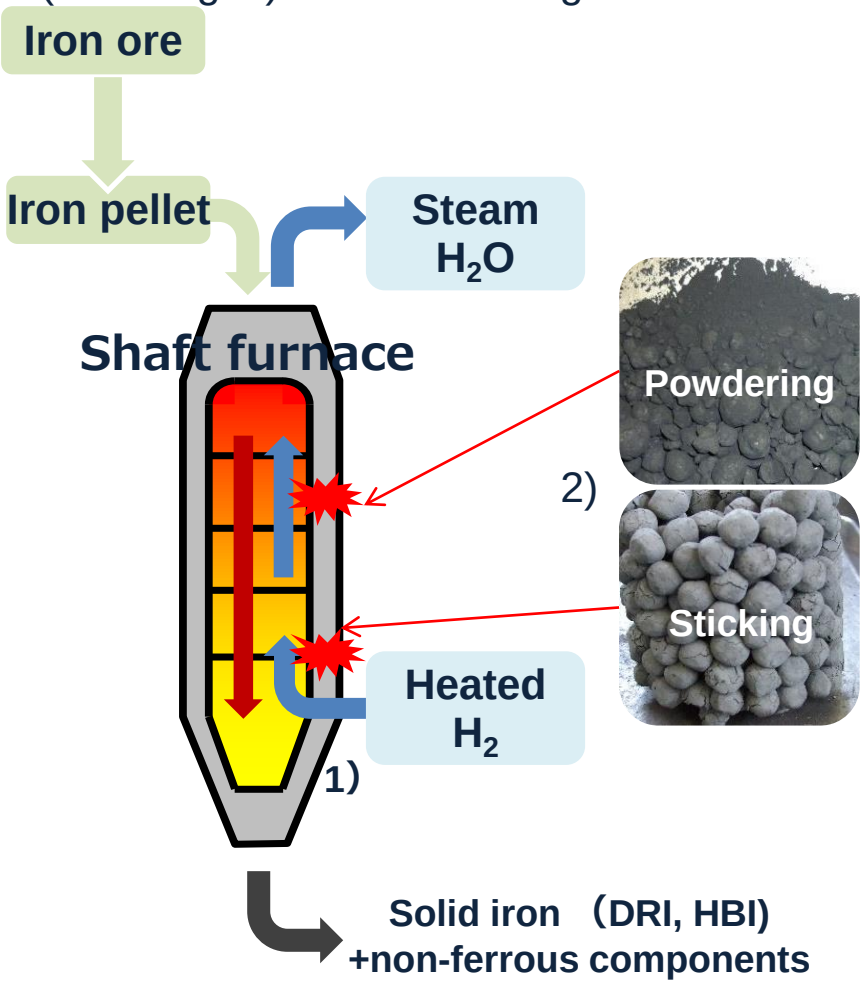
Currently, high-grade ores used as raw materials for reduced iron are scarce, accounting for only about 5% of total iron ore production, and a shift to reduced iron production using low-grade ores is essential.
We are challenging to develop technology for a direct reduction process that uses low-grade ore as raw material and 100% hydrogen instead of methane (natural gas) as the reducing material.

Problems

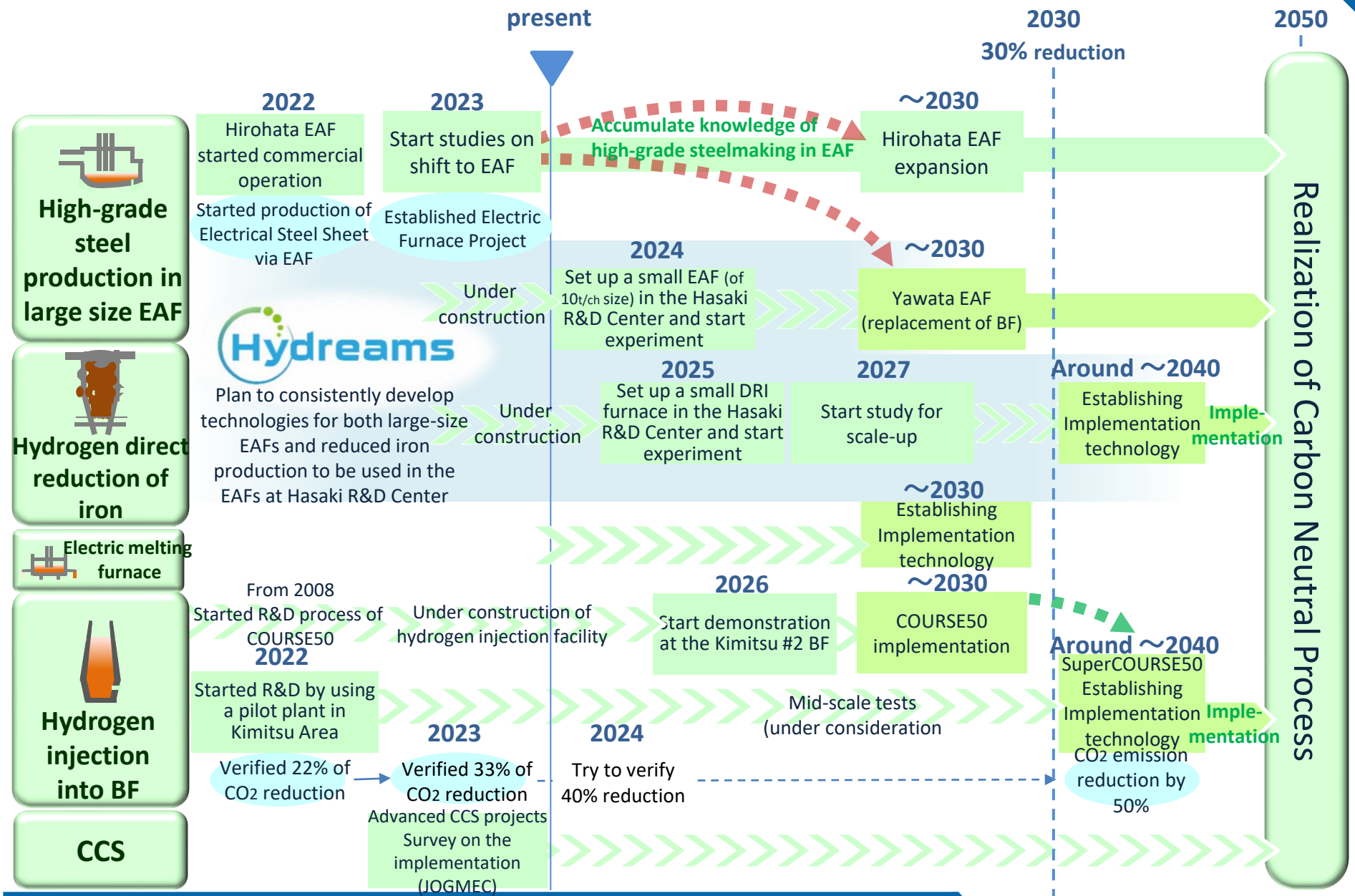
In addition to the issues of the existing DRI process,
1) Hydrogen reduction is endothermic.
→ Hydrogen preheating to be required.
2) Powdering of raw materials at low temperature and sticking of products.
→ Less powdering and less sticking ore (only 10% of commercially available ores) to be fed, so usage restrictions of raw materials are greater than BF method.

Challenge

Technologies for blowing a large amount of preheated flammable gases at high-temperature into the furnace, and expanding ores applicable to the hydrogen process



Carbon Neutral Vision 2050



To realize carbon neutral

Three Factors to increase costs

a)Huge R&D costs
b)Huge CAPEX
for practical implementation
c)Increase in operational cost

- Financial support for R&D and practical implementation
- Equal-footing in international competition

Support for every single step of Initiatives from R&D to social implementation

a) R&D	b) Practical implementation	c) Electricity & Hydrogen Cost	d) Raw materials

Green Innovation Fund adoption

GI fund

Use of hydrogen in steelmaking process

As of Dec., 2021		Addition ~Mar. , 2024.3		Total
193.5 Bn,	+	256.4 Bn.	=	**449.9 Bn.**

(unit: JPY)

R&D Item #1

Development of hydrogen injection into BFs

(1)Development of hydrogen reduction technology utilizing on-site hydrogen	14.0 Bn.	+ 29.6 Bn.	=	**43.6 Bn.**
(2)Development of low-carbon technology utilizing hydrogen from external sources and CO_2 contained in BF gas	121.4 Bn.	+ 117.2 Bn.	=	**238.6 Bn.**

R&D Item #2

Development of hydrogen direct reduction technology: low-grade iron ore reduction only by using hydrogen

(1)Development of direct hydrogen reduction technology	34.5 Bn.	+ 79.6 Bn.	=	**114.1 Bn.**
(2)Development of impurity removal technology for EAFs using direct reduced iron	23.6 Bn.	+ 7.0 Bn.	=	**30.6 Bn.**
(3)Development of technologies such as high-efficiency melting by an electric melting furnace using directly reduced iron		23.0 Bn.	=	**23.0 Bn.**

Corresponding technologies that NSC has been pushing forward

COURSE50 BF

SUPERCOURSE50 BF

100% hydrogen use in direct reduction process (shaft furanace etc.))

Production of high-grade steel in large size EAFs

Electric Melting Furnace

GI (Green Innovation) Fund : A government fund to provide continuous support to companies and others committed to ambitious goals to achieve carbon neutrality by 2050, from R&D and demonstration to social implementation, for a period of 10 years.

3 challenges for achieving a carbon-neutral society

Technology development	● Discovery of technology development seeds and securing of budget (completed) ● A development project is underway
Predictability of investment recovery	● Technical review for implementation (in progress) ● **Determine the predictability of investment recovery and strategic significance**, including government support and green steel market formation ● Green steel market formation Turning the **environmental value** (CO2 reduction) to the **economic value**
Infrastructure	● **Electric Power System Reform (7th Strategic Energy Plan)** Comprehensive power supply and demand measures and safe utilization of nuclear technology ● **Social implementation of hydrogen, ammonia, and CCUS**

Efforts to surmount the 3 challenges

Lobbying to the entire society, with a focus on making policy and institutional proposals to the government and industry

Technology development	Gov't support in development planning and testing	**Green Innovation (GI) Fund** "Utilization of hydrogen in the steelmaking process " ¥193.5 bln ➡ Raised to **¥449.9** bln	• • •	Budgeting completed
Predictability of investment recovery	Gov't support for capital expenditures	**One-third** of the total investment borne by the government by use of **GX Transition Bonds**	• • •	Institutionalization completed
	Gov't support for operating costs	Establishment of **a strategic materials and production base tax system** (Green Steel)	• • •	Institutionalization completed
	International standardization	**Adoption of the mass balance method** at Worldsteel **and development of guidelines**	• • •	High-level agreement in principle
		Lobbying for revision of ISO, GHG protocol, etc.	• • •	Implementing and preparing
	Creation of economic value from the environmental value (CO_2 reduction)	**GX League** [Ministry of Economy, Trade and Industry] ➡ Growth-oriented carbon pricing **GX Product Market Study Group** [Ministry of Economy, Trade and Industry] and the Government **GX Implementation Committee** Exchange of opinions with **the automobile industry** and others	• • •	Start of discussion on GX market creation
Infrastructure	Energy infrastructure development	Safe use of nuclear and other energy sources for the **7th Strategic Energy Plan**	• • •	Committee recommendations
		Hydrogen and Ammonia: Revised Basic Hydrogen Strategy, **Hydrogen Society Promotion Law**	• • •	Bill passed
		CCS: **JOGMEC/Advanced CCS Support Program**	• • •	Project participation

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