Environmental Vision 2050

JFE Steel Corporation

Carbon Neutrality Strategy Briefing

September 1, 2022

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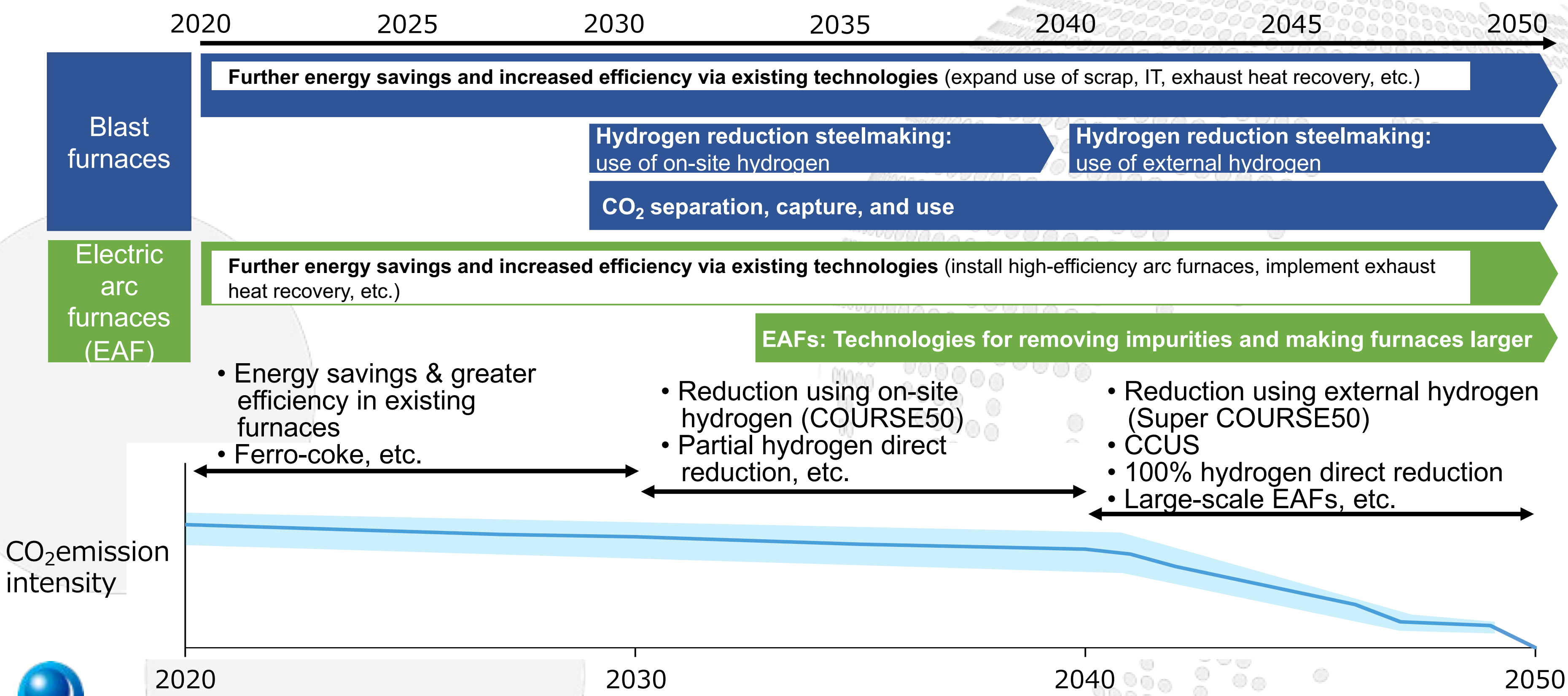
01 Carbon Neutrality Plan

- Carbon Neutrality Plan for Japanese Steel Industry (METI)
- JFE Steel’s Transition to Low-carbon Processes
- JFE Steel’s Carbon Neutrality Vision 2050

Carbon Neutrality Plan for Japanese Steel Industry (METI)

- **Multitrack approach to develop ultra-innovative technologies that will help the Japanese steel industry achieve carbon neutrality by 2050**
- **During the transitional period, expand the use of scrap via conventional technologies (energy savings, high efficiency, etc.), electric arc furnace (EAF) process, etc.**
- **Implement ultra-innovative technologies from 2040 aimed at major reductions in CO_2 emissions**



Source: METI
(https://www.meti.go.jp/policy/energy_environment/global_warming/transition/transition_finance_technology_roadmap_iron_and_steel_jpn.pdf)

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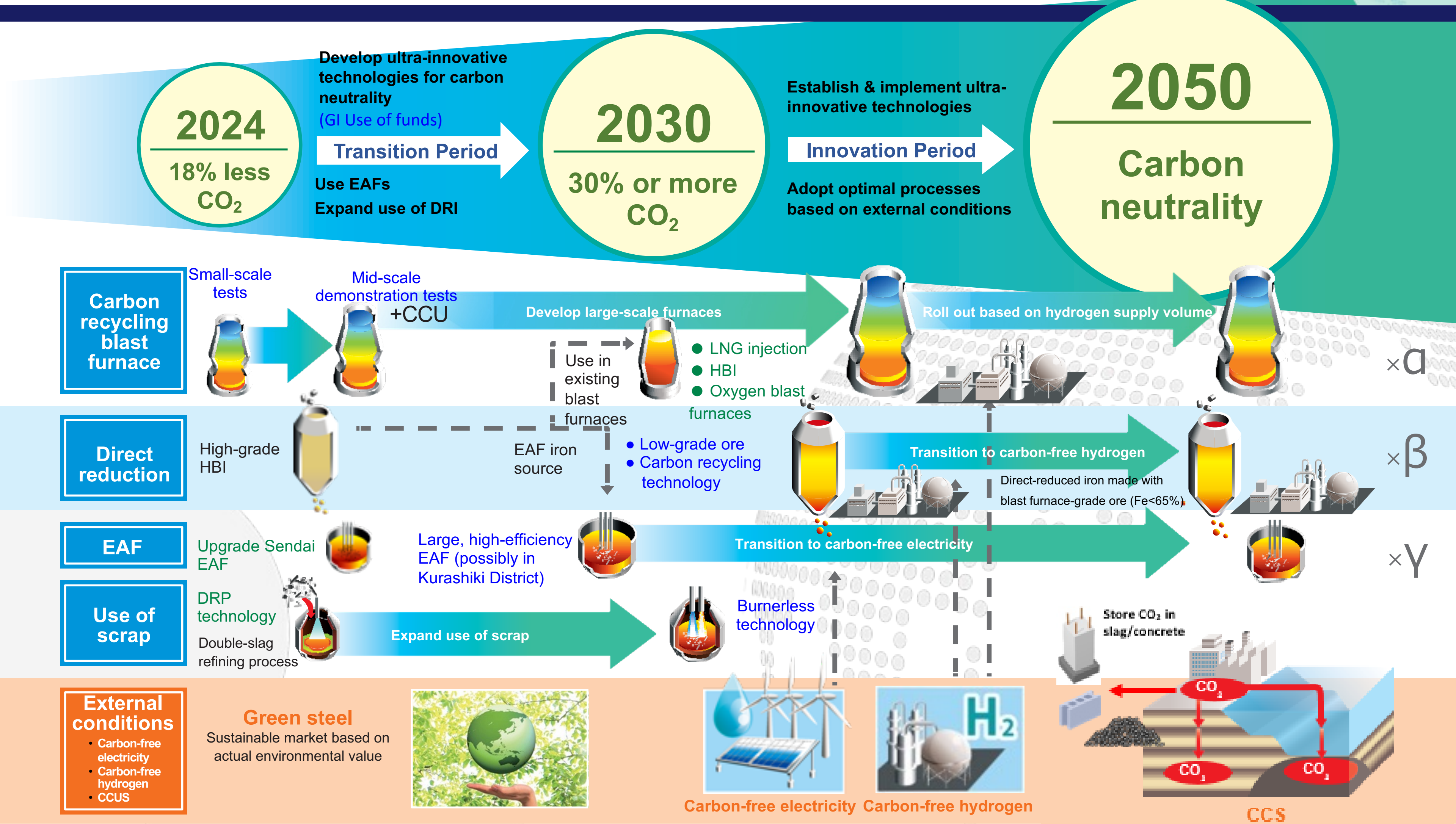
JFE Steel's Transition to Low-carbon Processes



Pursue multilayered technology development, via GI Fund projects, etc., to discover the most proven technologies and then achieve carbon neutrality by deploying the most optimized configuration of green steelmaking processes.

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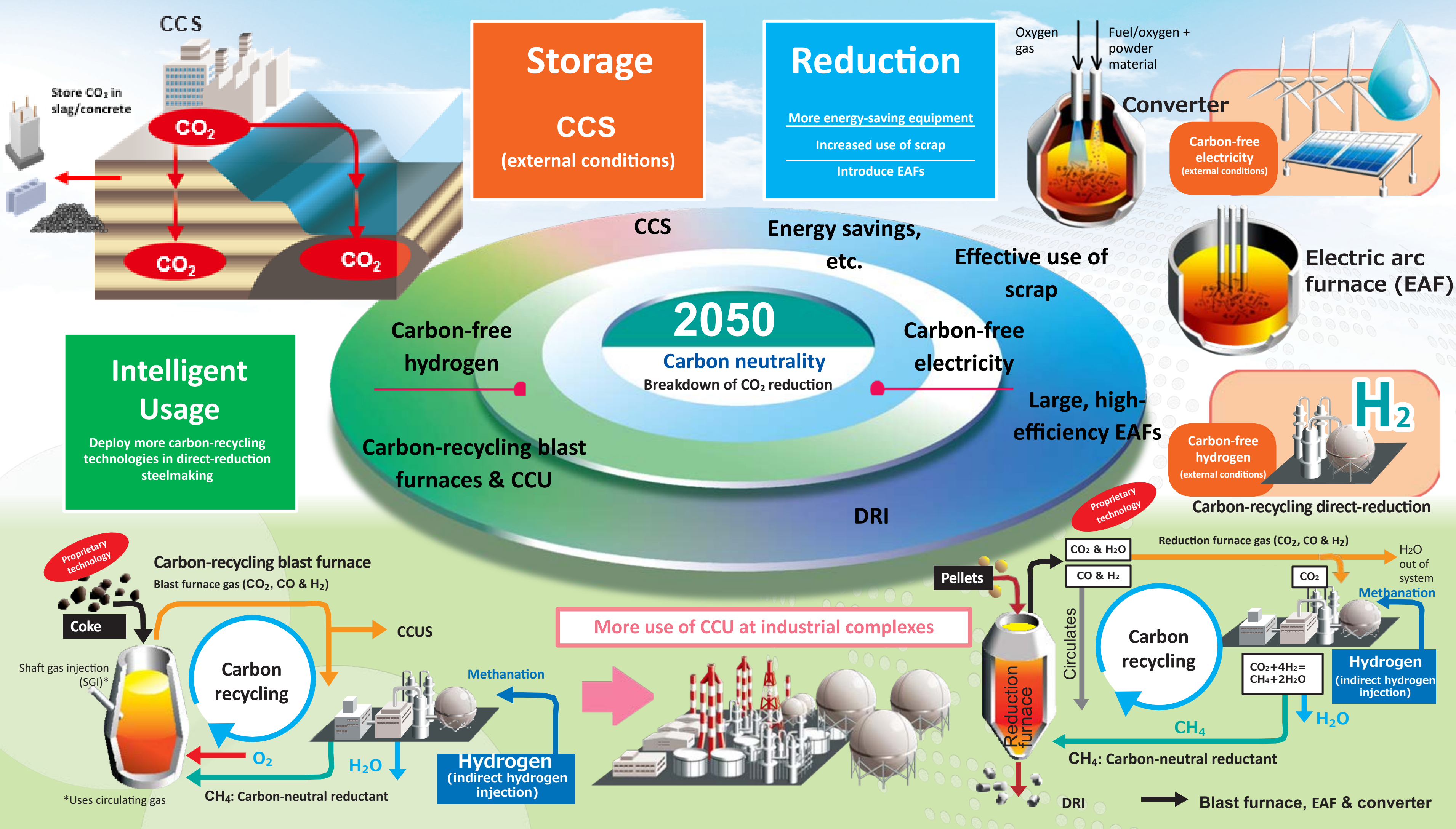
JFE Steel's Carbon Neutrality Vision 2050

Environmental Vision 2050



Combine reduction, intelligent usage and CO_2 storage to realize a carbon-neutral steel business by 2050

02 Carbon Neutrality Action Plan

JFE's Carbon Neutrality Action Plan

- JFE Steel is introducing low-carbon steel processes during its "transition period" to 2030.
- In its "innovation period" from 2030 to 2050, JFE Steel aims to develop and implement ultra-innovative technologies for carbon neutrality.

Transition period

- Increasingly deploy low-carbon technologies through capital investment to achieve targets such as cutting 2013-level CO_2 emissions by 30% or more by 2030
- Accelerate multitrack R&D targeting ultra-innovative technologies for innovation period
- Create markets for renewable green-steel materials based on actual environmental value
  → Create initial demand

Stimulate demand through government policy

Innovation period

- Swiftly establish and deploy ultra-innovative technologies
- Collaborate with communities and industrial complexes toward carbon neutrality
- Grow markets for sustainable green steel based on actual environmental value
  →Grow demand leading to virtuous cycles

Maintain the competitiveness of Japanese steel through plentiful, low-cost, stable supplies of carbon-free hydrogen and electricity

Behavior must be shifted on both supply and demand sides to create markets for green steel

03 30% Less CO_2 Emissions by 2030

- Transition to Low-carbon Processes
- Expand Use of Scrap in Converters
- Expand Use of Scrap in EAFs
- Produce Direct-reduced Iron

Transition to Low-carbon Processes

- ▶ Continue to develop ultra-innovative technologies for decarbonized steel processes by 2030
- ▶ Increasingly use low-carbon technologies to cut CO_2 by 30% or more by FY2030

Energy savings and high efficiency	Low-carbon feedstock & fuel	Low-carbon processes
Upgrade to high-efficiency coke ovens Fukuyama District (2025)	**Expand use of scrap in converters** **Use direct-reduced iron (HBI)** All districts (under way)	**Upgrade existing EAFs** Sendai Works (2024)
Improve efficiency of power-demand facilities (Electrify blast-furnace blowers, raise efficiency of oxygen plants, etc.) All districts (under way)	**Securing Scrap and HBI** **Reinforcing storage depots** All districts (under way)	**Introduce large, high-efficiency EAFs** Kurashiki District (2027-2030)
Leverage AI & DS (companywide CPS, etc.) for energy savings All districts (under way)	**Bolster LNG supply network**	**Use ferro-coke for commercial production** Fukuyama District (TBD)

- ✓ To reduce CO_2 emissions by 30% or more by 2030, 1 trillion yen in capital investment will be needed for low-carbon initiatives (large electric furnaces, ferro coke, scrap and reduced iron, LNG, etc.).
- ✓ A market that reflects the actual environmental value of green steel must be created to support capital investment in decarbonization technologies.

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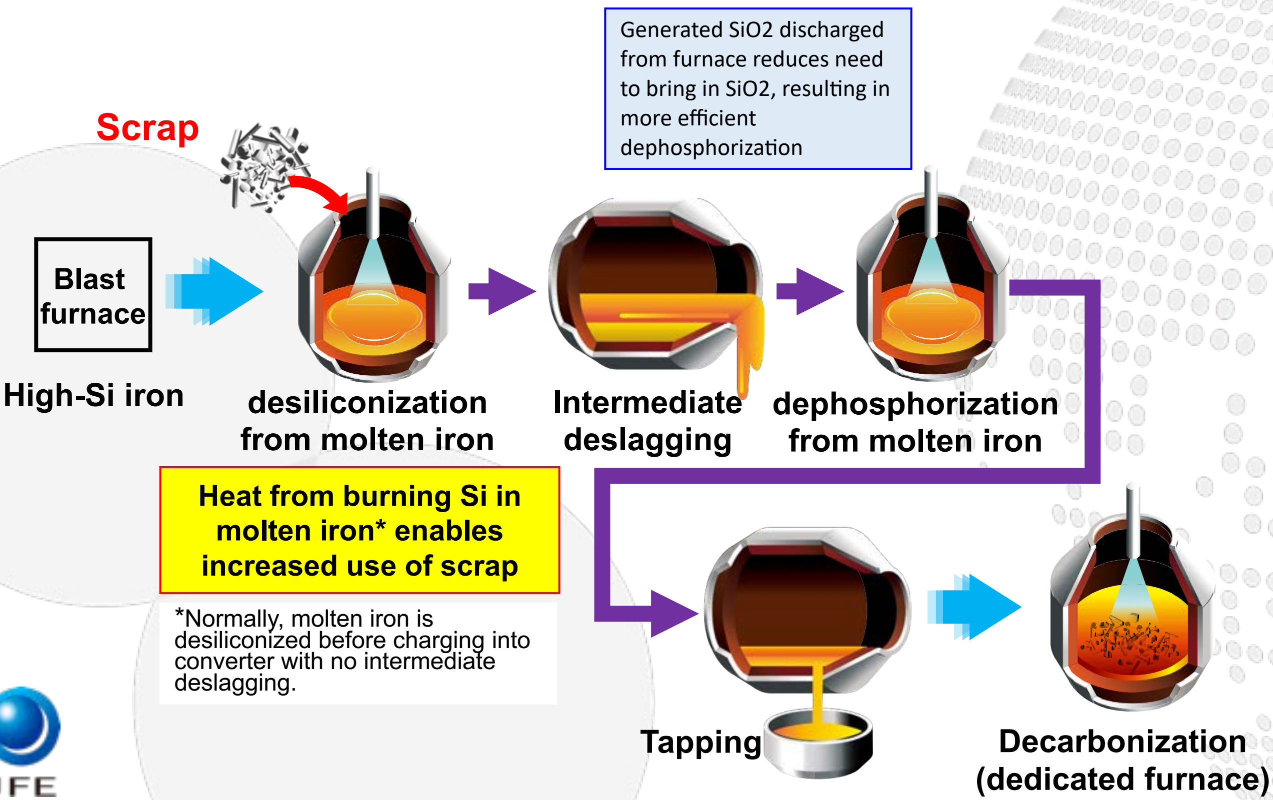
Expand Use of Scrap in Converters

- Eco-friendly converter-type molten-iron pretreatment process (DRP®) deployed companywide as of 2021, helping to cut CO_2 emissions by some 170,000 tons in FY2021
- Develop technology to increase heating margins to enable expanded scrape use and invest in facility expansions to reduce CO_2 by some 2 millions tons/year by FY2030.

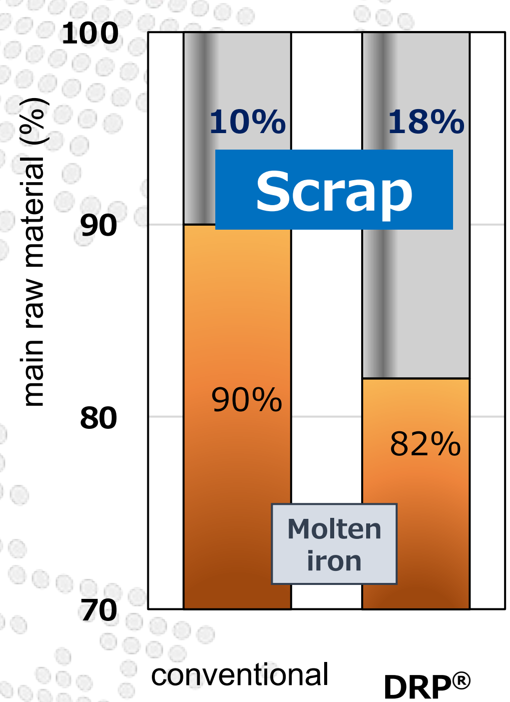
Eco-friendly Double-slag Refining Process (DRP®)



Heat from burning Si in molten iron* enables increased use of scrap

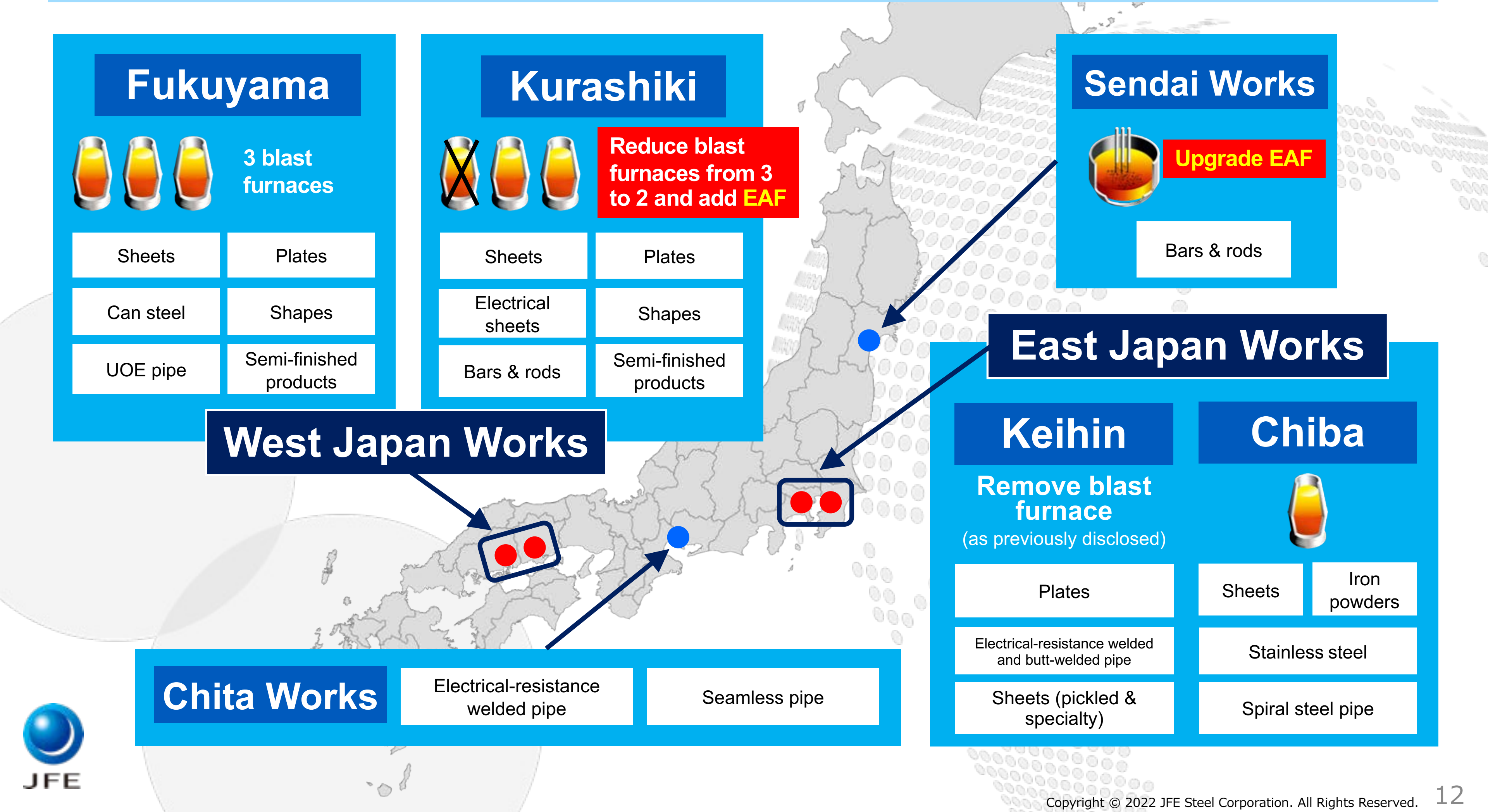
*Normally, molten iron is desiliconized before charging into converter with no intermediate deslagging.

DRP® for More Scrap Use



Expand Use of Scrap in EAFs (1)

- Upgrade Sendai Works' existing EAF to reduce CO_2 emissions by 30% or more by 2030
- Consider introducing large, high-efficiency EAF at West Japan Works' Kurashiki District



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Expand Use of Scrap in EAFs

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Upgrade Sendai EAF

▶ Use DX and other means, including upgraded cargo-handling equipment, to raise production capacity to 140,000 tons/year by 2024

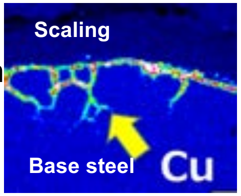
CO_2 reduction target: 100,000 tons/year

▶ Improve EAF material quality by developing technology to reduce impact of tramp elements (Cu, etc.) in existing materials

→ Raise eco-friendly product sales capacity to meet customer needs

✓ **Optimize steel composition:** Create ideal balance of elements to achieve mechanical properties and workability equivalent to blast furnace steel

✓ **Heating/rolling technology development:** Optimize conditions for suppressing surface defects caused by grain boundary infiltration of Cu in scrap during heating

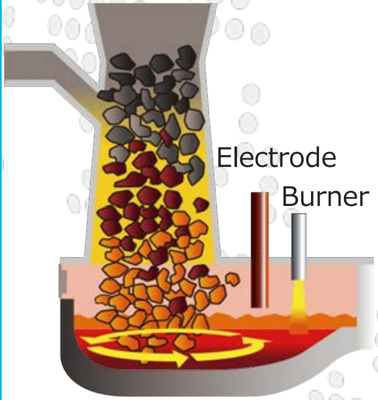


Build large, high-efficiency EAF

▶ Possibly introduce large, high-efficiency EAF

- Concurrently shut down one blast furnace slated for refurbishing (between 2027 and 2030) in Kurashiki District

- Enhance steel production efficiency and quality by developing technology at GI Fund's test-EAF in Chiba District, combined with JFE's own EAF technology



Technology for developing large EAFs

- Reduce electricity through high-efficiency preheating technology (for cold iron sources) and burner-based heating
- Utilize technology for high-efficiency adding/melting of large amounts of direct-reduced iron, combined with molten steel agitation technology

CO_2 reduction target: 3 millions tons/year

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Direct-reduced Iron Feasibility Studies

- In the transition period until 2030, the production of high-quality steel in electric arc furnaces will require high-grade direct-reduced iron, but supplies are limited.
- JFE Steel, Emirates Steel (UAE) and ITOCHU have agreed to conduct detailed feasibility studies aimed at building a supply chain for ferrous material.
- Aim is to construct a reduction furnace with an output capacity of 2.5 million tons per year, with some of the direct-reduced iron going to JFE Steel.

Supplier of high-grade iron ore

ITOCHU

Partners conduct detailed feasibility studies aimed at building a supply chain of the Ferrous Material

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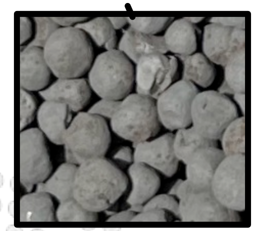
JFE Steel and other steel companies

High-grade iron ore

Reduce CO_2 emissions by using natural gas instead of coke as the reductant, and CCUS solutions, incl. enhanced oil recovery (EOR)



Ferrous Raw Material for Green Ironmaking with Low-carbon Emission

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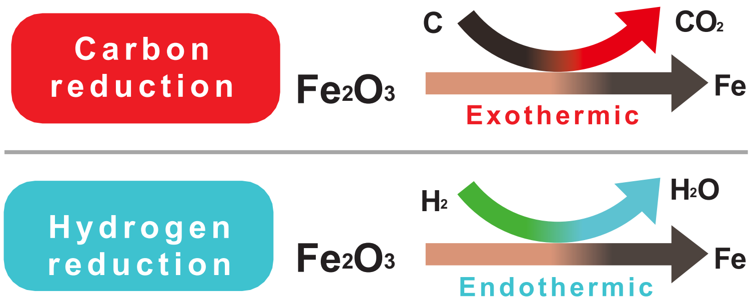
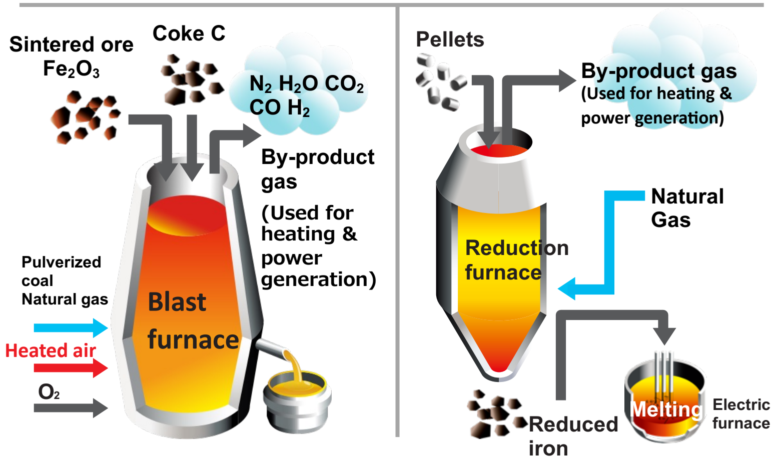
04 Multitrack R&D Targeting Ultra-Innovative Technologies

- Challenges in Developing CO_2 Reduction for Steelmaking
- Development Project Supported by Green Innovation Fund
- Overall Scale of GI Fund Projects
- GI Fund Project for Reducing CO_2 via CR Blast Furnaces
- GI Fund Project for Direct Hydrogen Reduction
- GI Fund Project for Large, High-efficiency EAFs

Challenges in Developing CO_2 Reduction for Steelmaking

Challenge 1: Supplying heat during hydrogen reduction

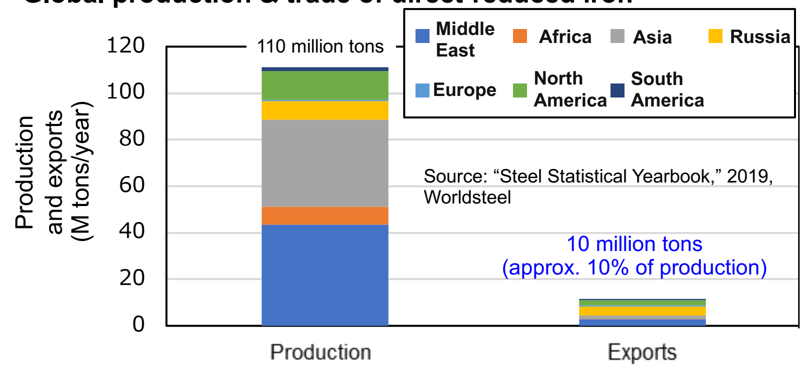




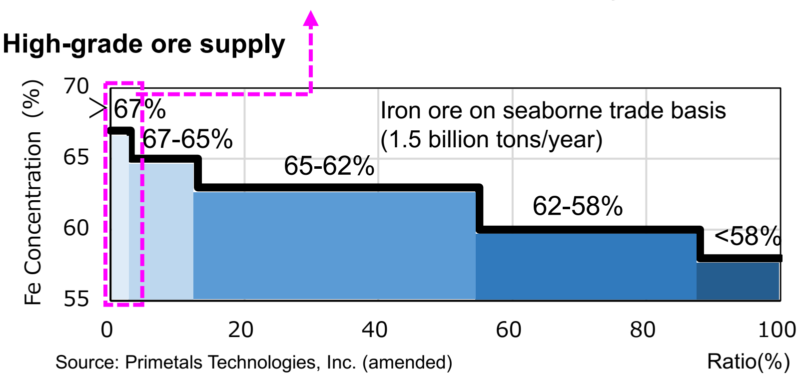
- ▶ Steelmaking requires a reducing reaction that removes oxygen from the iron ore.
- ▶ Hydrogen reduction is endothermic, so heat must be supplied to both blast furnaces and reduction furnaces

Challenge 2: Securing cold iron sources

Global production & trade of direct-reduced iron



High-grade ore supply



Source: Primetals Technologies, Inc. (amended)

- ▶ About 100 million tons of high-grade direct-reduced iron is required to produce high-quality steel in electric arc furnaces
- ▶ Raw materials are currently limited to high-grade raw materials, so technologies for using low-grade raw materials are needed.

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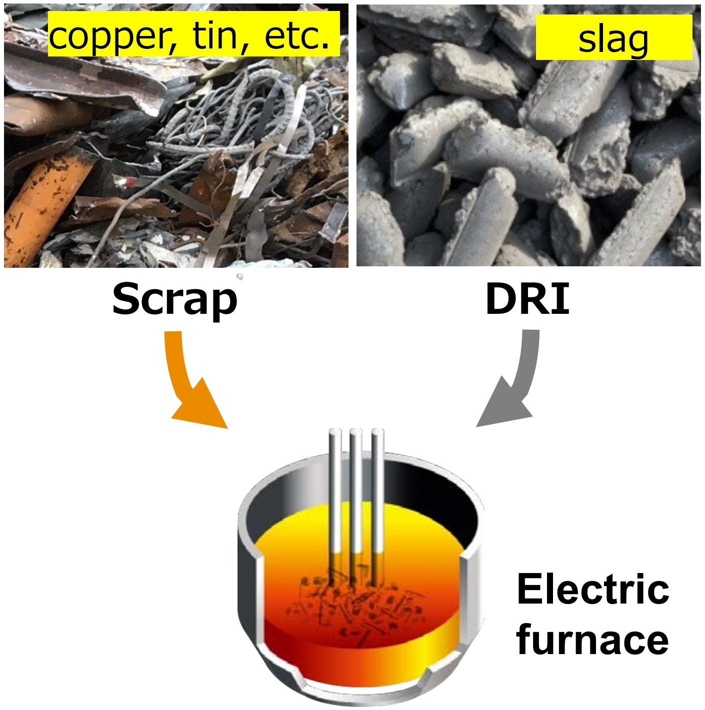
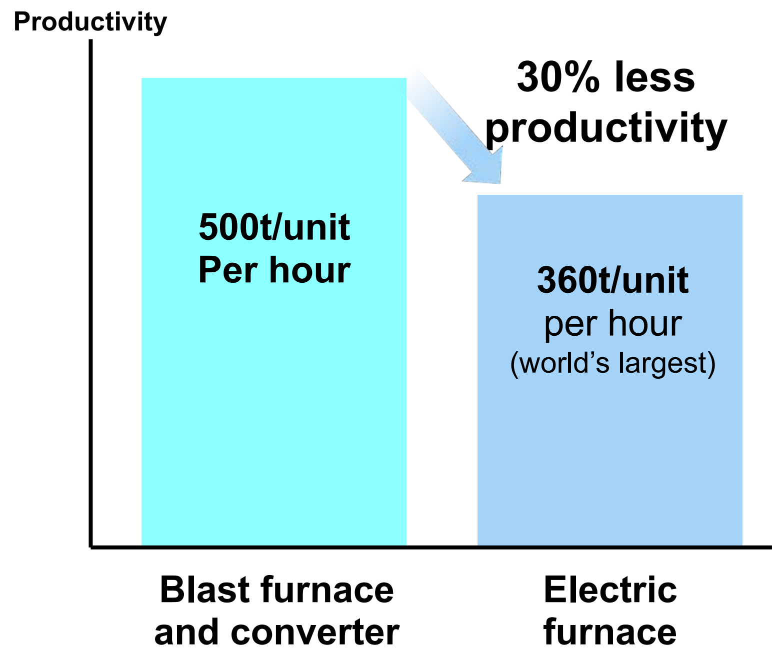
Challenges in Developing CO_2 Reduction for Steelmaking

Challenge 3: Impurities in scrap



- ▶ Scrap contains impurities, such as copper and tin, while direct-reduced iron contains impurities such as slag
- ▶ Efficient production of high-quality steel from iron with many impurities is difficult.

Challenge 4: Productivity of electric furnaces



Source: Jumbo size 420t twin DC FastArc®EAF, Millennium Steel, 2011

- ▶ Electric melting from cold iron sources such as scrap is significantly less productive than converter furnaces.
- ▶ Using direct-reduced iron lowers productivity and increases electricity consumption.

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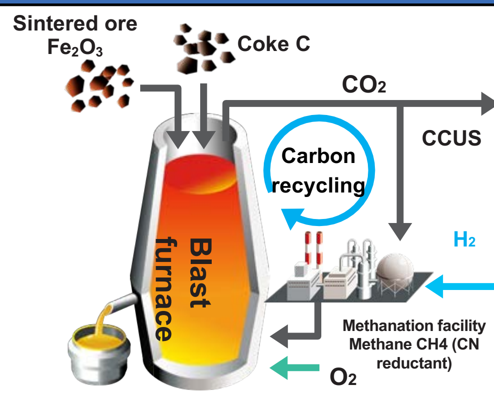
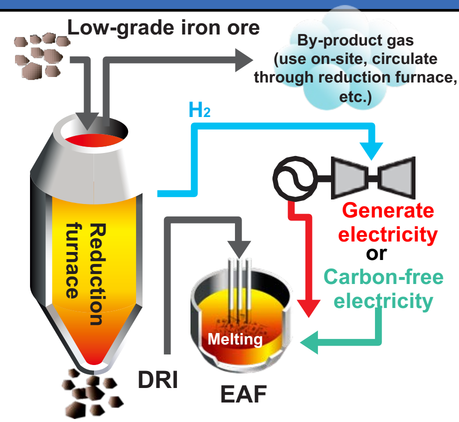
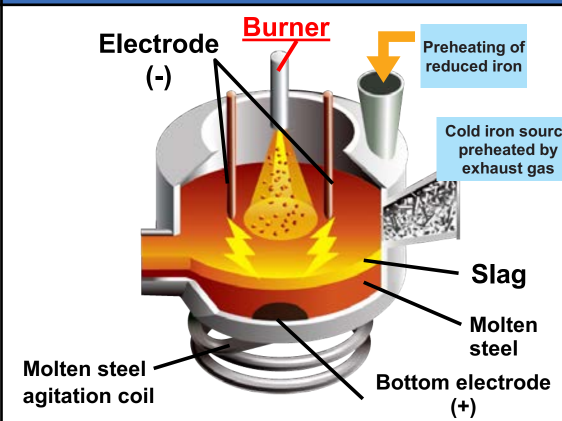
Development Project Supported by Green Innovation Fund

- This project, targeted at using hydrogen in ironmaking and commissioned and subsidized by NEDO*, was selected in December 2021 to receive support from the Green Innovation Fund.
- The fund is helping to accelerate the development of technologies for achieving carbon neutrality.
- Formed a consortium with three steel companies and JRCM** and held the first meeting of the Hydrogen Iron and Steel Committee in June 2022.

*New Energy and Industrial Technology Development Organization **Japan Research and Development Center for Metals

	Carbon-recycling blast furnace	Direct-reduction steelmaking	Large, high-efficiency EAF
Development project			
Summary	Build a small test blast furnace (150m^3) in Chiba District Prefecture to develop a process for converting CO_2 by-product into methane for reuse as a reductant, aiming to cut CO_2 emissions by 50% or more.	Build a small test reduction furnace in Chiba District Prefecture to develop a direct-reduction ironmaking process for reduced iron that uses hydrogen to remove oxygen from low-grade iron ore, aiming to cut CO_2 emissions by 50% or more vs. blast furnaces.	Build a small test EAF in Chiba District Prefecture to develop a high-quality steel manufacturing method incorporating high-efficiency melting of scrap and reduced iron, reduction of impurities, etc.

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Overall Scale of GI Fund Projects

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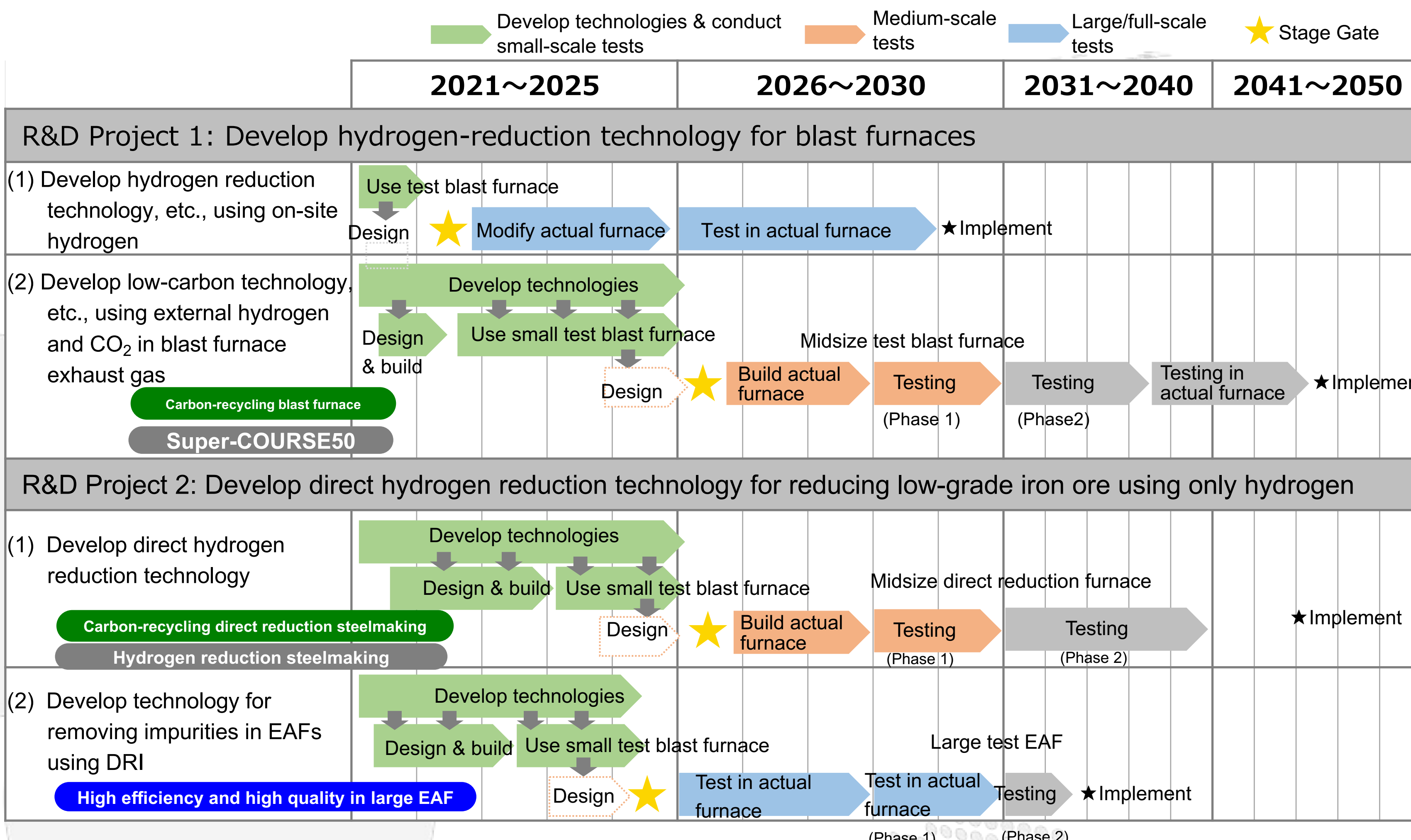
- ▶ Development toward Stage Gate Reviews scheduled mainly in FY2025–2026
- ▶ Studies also underway with a view to actual implementation in 2030–2040s



Note: All schedules are projections

Source: METI
(https://www.meti.go.jp/policy/energy_environment/global_warming/gifund/pdf/gif_05_randd.pdf)

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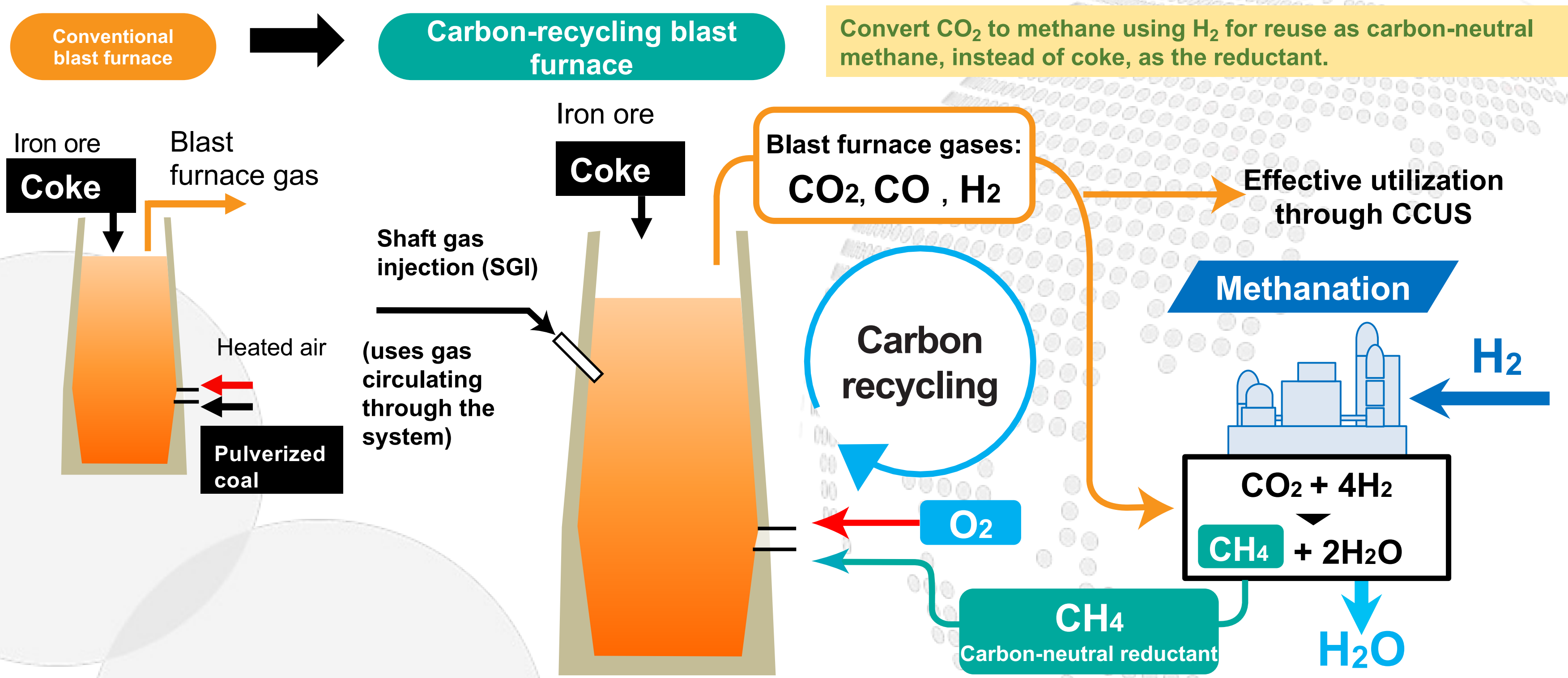
GI Fund Project for Reducing CO_2 via CR Blast Furnaces

- ▶Build small carbon-recycling test blast furnace (150m³) in East Japan Works' Chiba District
- ▶Conduct trial operation to verify basic principles (Apr. 2025 – FY2026)
- ▶Conduct demonstration tests, aiming to reduce CO_2 emissions by 50% or more vs. conventional blast furnaces



Path to implementation*: By 2030, conduct medium-scale blast furnace demonstration tests (up to 700m³ in Kurashiki District) using pure oxygen & medium-pressure ("city") gas, and then consider conducting demonstration tests, or actual implementation, of a full-scale furnace at an early stage

*Post-stage gate plans TBD

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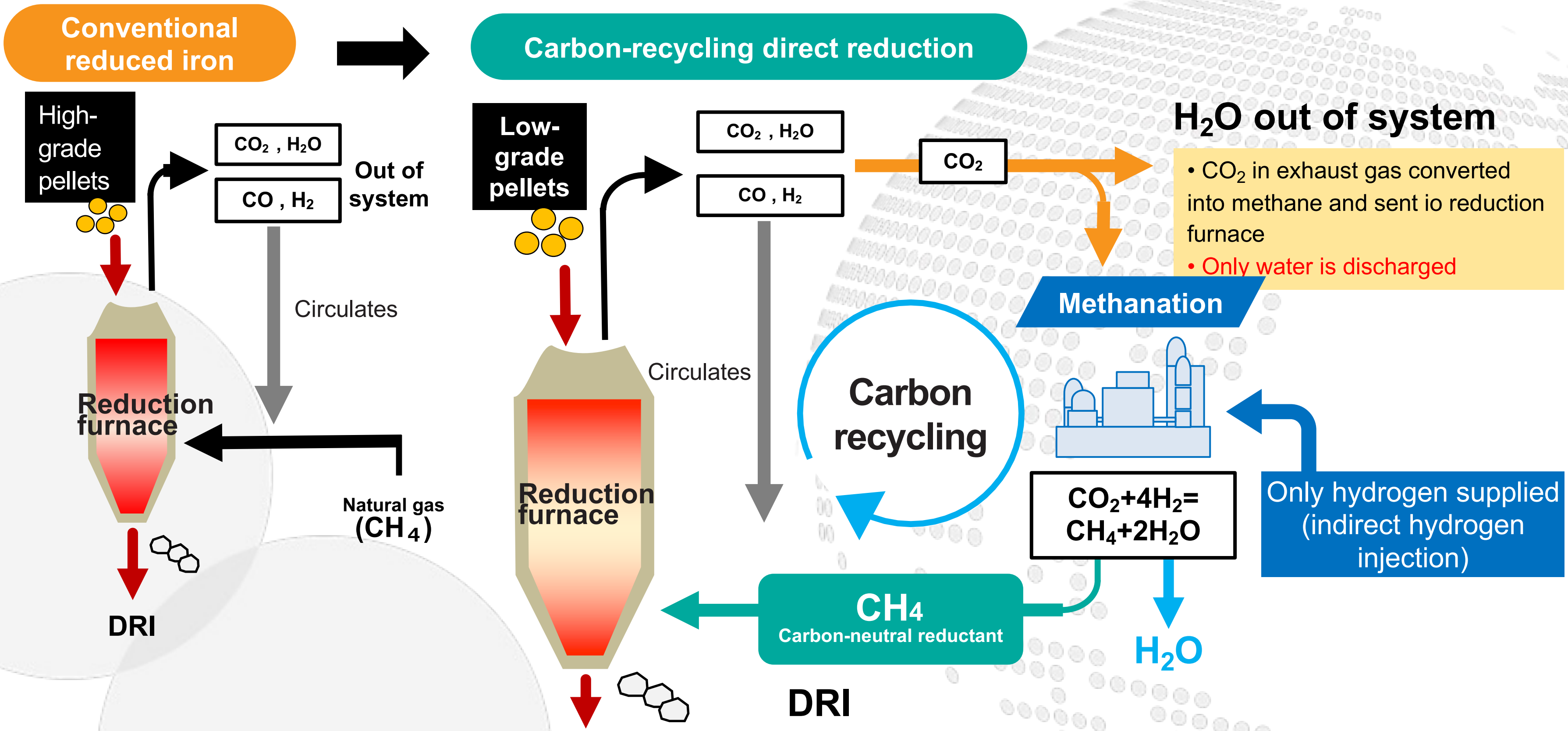
GI Fund Project for Direct Hydrogen Reduction

▶Build a small bench-test furnace in East Japan Works' Chiba District and start testing in 2024.

▶JFE Steel will handle direct carbon recycling (indirect hydrogen injection), which utilizes methanation, traps carbon in the process for recirculation, and overcomes heat absorption in hydrogen reduction.



Path to implementation*: Conduct technology validation at a larger plant and then consider conducting demonstration tests, or actual implementation, of a full-scale furnace at an early stage.

*Post-stage gate plans TBD

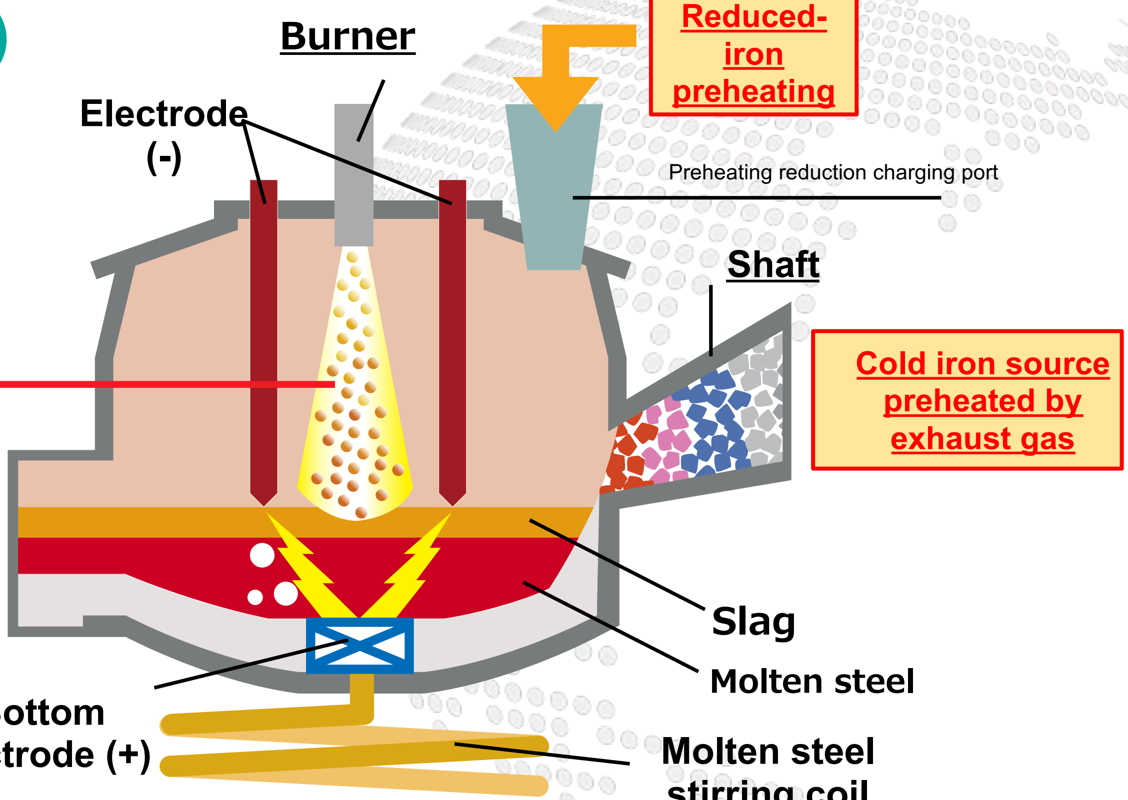
GI Fund Project for Large, High-efficiency EAFs

- Build a small test EAF (10 tons) in the East Japan Works' Chiba District and start testing in FY2024.
- Combine reduced-iron-preheating, heating-burner and molten-steel-agitation technologies in a process aimed at reducing EAF-melting power consumption and enabling high-speed melting of cold iron sources (scrap & reduced iron).

Large, high-efficiency and high-quality EAF

Powder-heating burner
Heating powder (refining agent & carbon material) with a burner while adding it to the furnace results in highly efficient heating.

Note: JFE Steel also built a 3-ton smelting furnace in Fukuyama District to develop a high-quality steel production method using scrap and reduced iron in an EAF.



Path to implementation*: Deploy technology from above GI Fund Project to construction JFE Steel's EAF

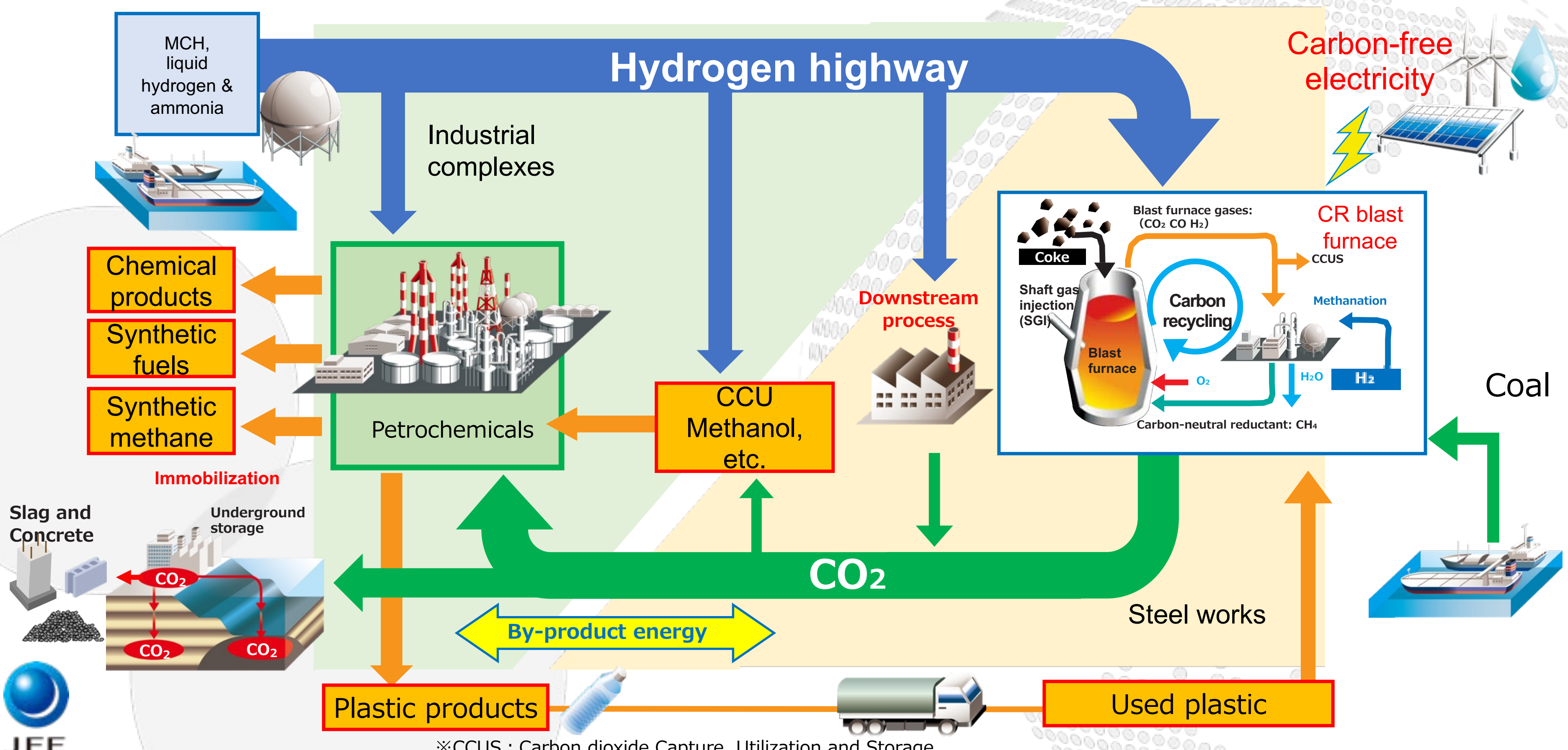
*Post-stage gate plans TBD

05 Initiatives for Effective Use of CO_2

- CCUS and Green Infrastructure Initiatives
- Port Initiatives Carbon Neutral
- CO_2-based Methanol Synthesis
- Storing CO_2 in Steel Slag

CCUS and Green Infrastructure Initiatives

- In addition to CCU-synthesis and CO_2-fixation technologies, large-scale CO_2 capture, utilization and storage (CCUS) solutions will be needed to achieve carbon neutrality by 2050, based on which necessary partnerships are beginning to be formed.
- Building a carbon-recycling society in which CO_2 is used as a new carbon resource will require major infrastructure construction and enhancement to supply huge amounts of hydrogen and carbon-free electricity. Institutions and societal support for accelerating private-sector collaboration also will be needed.

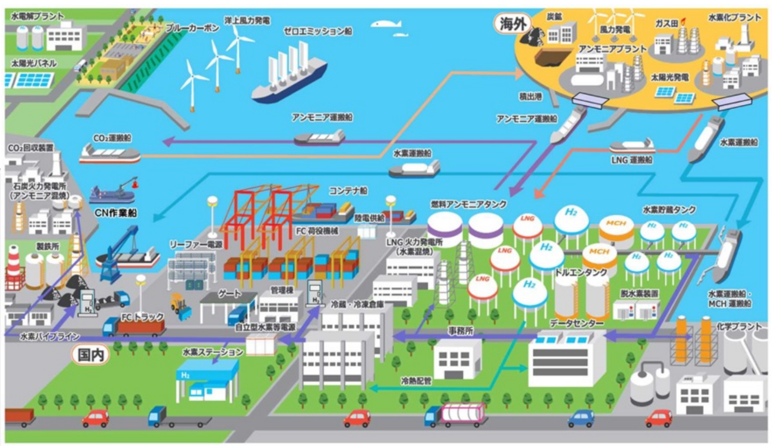


※CCUS : Carbon dioxide Capture, Utilization and Storage

Initiatives for Carbon-neutral Ports

- The ports of Kawasaki and Yokohama, which include the Keihin District of the JFE Steel's East Japan Works, are jointly implementing carbon-neutral port measures under a government-private sector initiative.
- ENEOS, JERA and JFE Holdings are studying a possible collaboration to establish a base for receiving and supplying hydrogen, ammonia, etc., in view of JFE's changing use of deep-water wharves and adjacent land due to structural reforms.

Carbon-neutral Ports



Source: Ministry of Land, Infrastructure, Transport and Tourism's Carbon Neutral Port Formation Planning Manual (https://www.mlit.go.jp/kowan/content/001447257.pdf)

- Receive and supply hydrogen, fuel ammonia, etc. from overseas
- Help to decarbonize port logistics
- Help to decarbonize nearby companies

Facilities in Ohgishima (site of JFE Steel's Keihin District) for receiving and supplying hydrogen, etc.

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CO_2-based Methanol Synthesis

- Construction of test facility in West Japan Works' Fukuyama District to start in FY2022.
- Startup expected in FY2023 and practical application testing to finish in FY2025.
- The aim is to build an optimal system based on low-cost CO_2 separation and high-efficiency methanol synthesis.

Note: This initiative has been commissioned by the New Energy and Industrial Technology Development Organization (NEDO) under a project named "Development of Technology for Carbon Recycling: Next-generation Coal-fired Power Generation and Development of Technology for Reducing CO_2 Emissions and the Practical Application of Effective Uses for CO_2."

Joint R&D undertaking with Research Institute of Innovative Technology for the Earth:

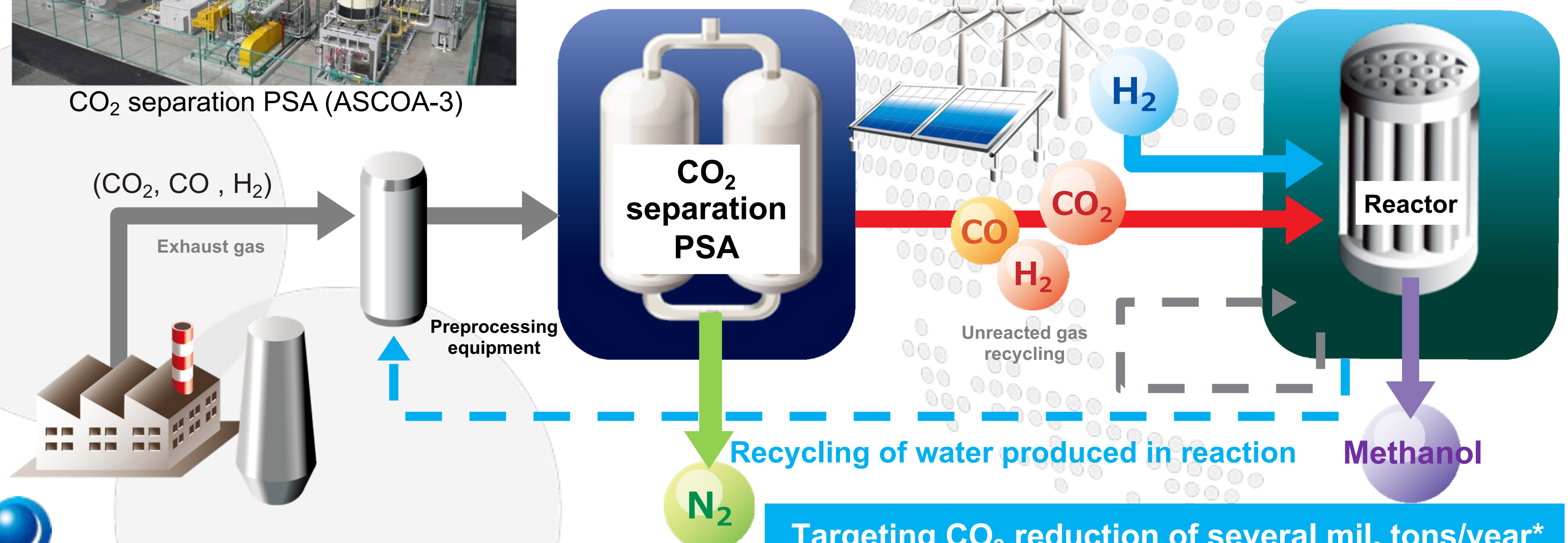
CO_2 separation PSA (ASCOA-3)

Low-cost CO_2 separation PSA

High-efficiency methanol synthesis reactor

Reaction efficiency >60%*

*20-30% with conventional methods



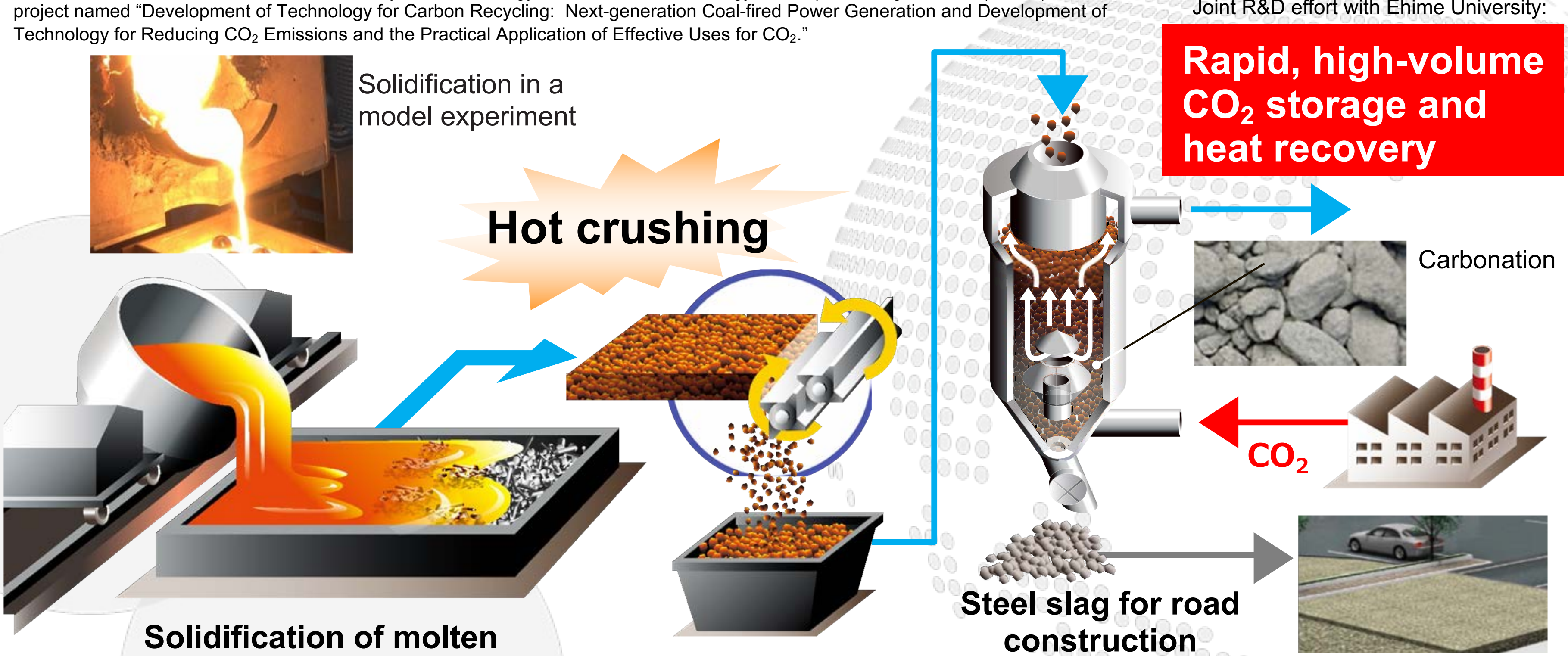
Targeting CO_2 reduction of several mil. tons/year*

*Assumes use of petroleum-derived chemicals as alternative base materials

Storing CO_2 in Steel Slag

- Practical application test facility to be built in East Japan Works' Chiba District from FY2023.
- Process principles to be verified by FY2022 and operation to be tested between FY2024 and FY2025.
- Verify technology for storing CO_2 in slag, heat recovery technology for high-temperature slag, and technology for using slag in road construction.

Note: This initiative has been commissioned by the New Energy and Industrial Technology Development Organization (NEDO) under a project named "Development of Technology for Carbon Recycling: Next-generation Coal-fired Power Generation and Development of Technology for Reducing CO_2 Emissions and the Practical Application of Effective Uses for CO_2."



Targeting CO_2 reduction of 300-350k tons/year

06 Collaborating with Society on Carbon Neutrality

- Stimulating Demand for Green Steel
- Initiatives for Collaborating with Society
- New Teams Overseeing Carbon-neutrality

Stimulating Demand for Green Steel

- In the EU, green steel is branded and sold using a mass balance approach.
- Achieving 30% CO_2 reduction by FY2030 will enable JFE Steel to supply up to 5M tons of green steel per year using the same approach.
- To create a carbon-neutral world, government policies need to encourage behavioral changes in both the supply and demand sides in order to drive changes in society and spark innovation for new industrial competitiveness.

Supply side

- Huge capital investment is needed to introduce low-carbon & ultra-innovative technologies. (1 trillion yen in low-carbon investments by 2030)
- While JFE Steel will strive to minimize R&D cost increases, some increase will be inevitable in the effort to create new environmental value.

- Prospects for appropriate returns on such investments also will be needed.

Demand side

- Green steel products do not directly benefit consumers in terms of better quality, performance, convenience, etc.
- Ethical consumption appears to be on the rise, but in Japan awareness of environmental value is low.

- Incentives are needed to encourage the recognition of environmental value and the purchase of products that significantly reduce carbon.

To support investment in low-carbon technology during the transition period until 2030 and to prepare for further large-scale investment during the innovation period, a green steel market must be created at an early stage (transition period) and government policies must raise the public's awareness as well as encourage steel consumers to change their behavior.

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Initiatives for Collaborating with Society

- **Realizing carbon-neutral steelmaking is a top priority for JFE Steel, but generating environmental value will involve large cost increases, so there are limits on what a single company can do.**
- **Mechanisms are needed so that society, as the beneficiary of green steel, helps to cover the associated cost increases through government support, collaborative initiatives, etc.**

Huge R&D and facility installation costs

- Achieving CN by 2050 will be a major technological challenge requiring huge R&D outlays.
- Transitioning steelworks to carbon-neutral processes will require even greater capital investment.
- Long-term government support will be needed to shoulder the financial costs of achieving carbon neutrality.

Deliver environmental value and create markets during transition

- Government support is needed for capital investment in low-carbon technologies by 2030
- A mechanism is needed to create a market where costs commensurate with green steel's environmental value can be shared with customers and society

Develop infrastructure for carbon-neutral steelmaking and fuel inter-company collaboration

- Develop infrastructure for the low-cost, stable, large-scale supply of carbon-free hydrogen and electricity needed for carbon-neutral steelmaking
- Develop an execution platform for CCUS and green infrastructure implementation through collaboration with industrial complexes, corporations, etc.

Economic policies targeting green-transformation investment and international competitiveness

- Ensure international competitiveness of industrial electricity prices
- Introduce tax system that encourages implementation of ultra-innovative technologies, such as the abolition of depreciable asset taxation and the avoidance of a carbon tax before the establishment of decarbonizing technologies
- Carbon Border Adjustment Measure (CBAM) should be consistent with WTO rules. Ensure a level playing field in cooperation with other countries

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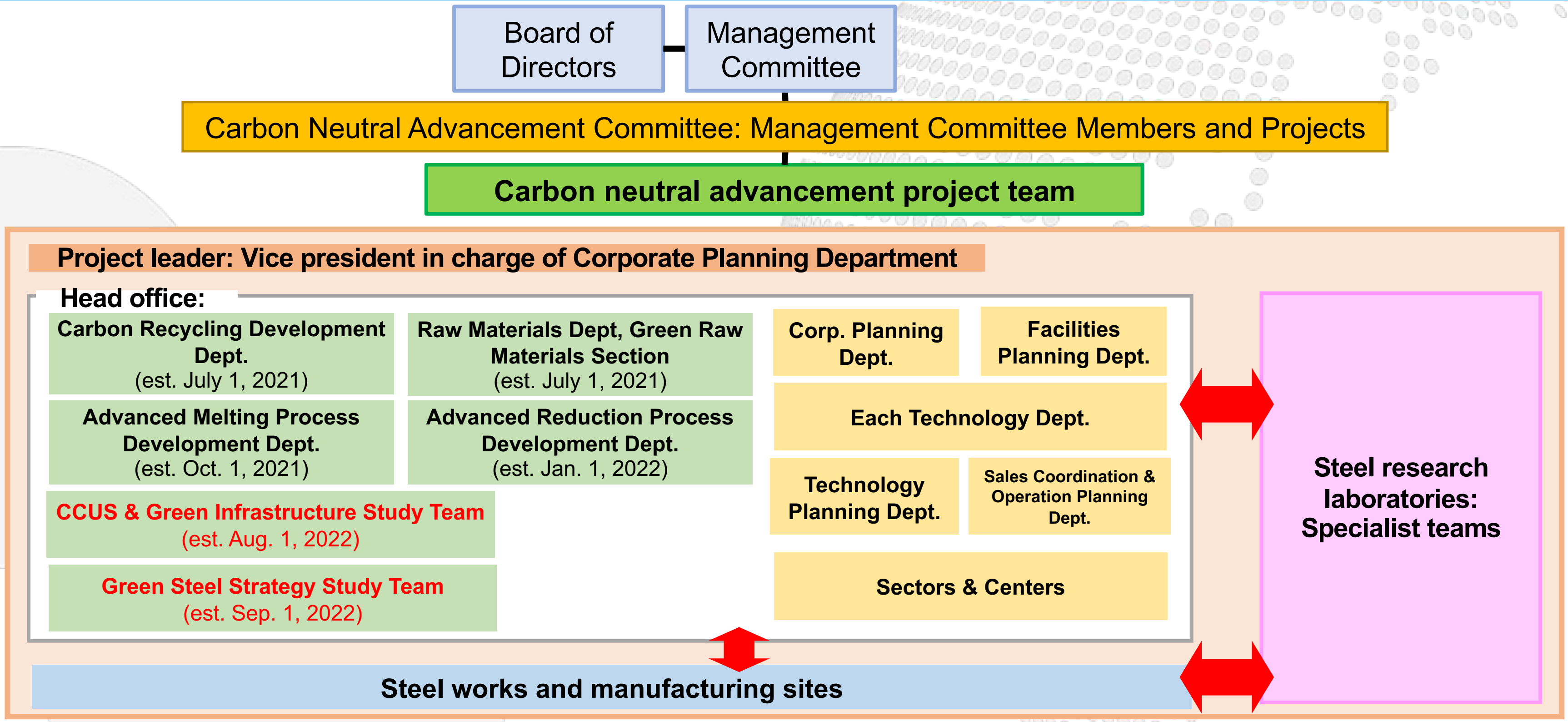
New Teams Overseeing Carbon Neutrality Promotion

▶ Establish new teams to oversee the achievement of carbon neutrality by 2050

✓ **CCUS and Green Infrastructure Study Team**
In addition to existing R&D, this team will oversee studies on CO_2 capture, utilization and storage technologies and the procurement of carbon-free hydrogen and electricity, including related collaboration with industrial complexes and other private companies.

✓ **Green Steel Strategy Study Team**
In addition to dealing with issues such as standardization and market strategy regarding green steel products, this team will develop strategies for new businesses, including solutions that leverage patents and rights to carbon-neutral process technologies.



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