Environmental Vision 2050

May 25, 2021

JFE Holdings, Inc.
Outline of JFE Group Environmental Vision for 2050
Based on our corporate philosophy of contributing to society with the world's most innovative technology, we will accelerate our research and development of new technologies and pursue super-innovative technologies to combat climate change.

In addition to addressing our business risks, we will seek business opportunities that allow us to help realize a more sustainable world and enhance our corporate value by contributing to CO₂ emissions reduction across society.

The philosophy of the Task Force on Climate-related Financial Disclosure (TCFD) will be reflected in our business strategies and deployed in a systematic manner.

2020 was the starting point for responding to climate change through CO₂-reduction activities.

Achieving carbon neutrality in 2050 is the most important issue in JFE’s medium-term business plan.

Climate change is an extremely important issue from the perspective of business continuity.

Global climate-change issues, such as increasingly abnormal weather, must be addressed urgently.
1. 7th Medium-term Business Plan Initiatives
   • Steel business: **Reduce steel-business CO₂ emissions in FY2024 by 18% vs. FY2013**

2. Initiatives for carbon neutrality by 2050
   a. Reduce CO₂ emissions at JFE Steel
      • **Pursue super-innovative technologies mainly for carbon-recycling blast furnaces and CCU**
      • Develop hydrogen-based ironmaking (direct-reduction) technology, maximize use of electric arc furnace technology, etc.

   b. Expand contributions to CO₂ emissions reduction in society
      • Engineering business: Expand and develop renewable-energy power generation and carbon-recycling technologies.
      • Steel business: Develop and market eco-products and eco-solutions.
      • Trading business: Increase trading in biomass fuels, steel scrap, etc. and strengthen business in supply chain management (SCM) for eco products.

   c. Accelerate groupwide commercialization of offshore wind-power business

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**R&D, etc. 50 billion yen**
**ST CAPEX for electrical steel sheet in Kurashiki 49 billion yen**
**EN monopile approx. 40 billion yen**

**JFE Group Environmental Vision for 2050**
Towards Carbon Neutrality

*(Group-wide investment in GX in the 7th Medium-term Business Plan: 340 billion yen)*

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**Steel business**: Reduce CO₂ emissions in FY2024 by 18% vs. FY2013
Drive JFE’s carbon neutrality by decarbonizing steel processes, etc.

**Engineering business**: Support carbon neutrality in society through expansion and development of renewable-energy power generation and CR technologies, etc.

**Steel business**: Carbon neutrality by 2050

<table>
<thead>
<tr>
<th>(Mt/year)</th>
<th>FY2013 (CO₂ reduction base year)</th>
<th>FY2024 (last year of 7th Medium-term Business Plan)</th>
<th>FY2030</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel business CO₂ emissions</td>
<td>58.1</td>
<td>47.6</td>
<td>25.0</td>
</tr>
<tr>
<td>CO₂ emissions reduction</td>
<td>-10.5</td>
<td>12.0</td>
<td>18%</td>
</tr>
<tr>
<td>Engineering business CO₂ emissions reduction</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

GX investment in steel business: 160 billion yen over 4 years
GX investment in engineering business: 130 billion yen over 4 years

CR: Carbon Recycling

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02 Steel-business Initiatives for Carbon Neutrality
Outline of Steelmaking Process
Steel Manufacturing Process

1.28 billion t/year
0.11 billion t/year
1.35 billion t/year
0.52 billion t/year
1.87 billion t/year

Source: 2019 data on production volumes, World Steel Association (WSA)
Blast furnace and converter method:
Carbon (reducing material) used to remove oxygen from iron oxide in iron ore
Combustion of carbon (heat resource) provides heat to melt iron
→More CO₂ generated compared to direct-reduction or electric-arc-furnace methods

<table>
<thead>
<tr>
<th>Method</th>
<th>CO₂ Emission (t)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast furnace and converter method</td>
<td>2.0</td>
</tr>
<tr>
<td>Direct reduction method</td>
<td>1.0-1.5</td>
</tr>
<tr>
<td>Electric arc furnace method</td>
<td>0.5</td>
</tr>
</tbody>
</table>

*1 JFE Group CSR Report (2020)
*2 Ultra-Low CO₂ Ironmaking: Transitioning to the Hydrogen Economy, Midrex Technologies, Inc. etc.
*3 Ferrum Vol. 3 (1998) No. 1, etc.
CO₂ Emissions in Steelmaking (Blast furnace and converter method)

- 14% of domestic CO₂ emissions come from steel manufacturing
- CO₂ reduction in ore reduction process is important to achieve carbon neutrality

Ratio of CO₂ emissions from steel manufacturing processes (t-CO₂/t-crude steel)

Most (over 80%) CO₂ emissions are from iron ore reduction process in blast furnaces

Source: “2050 Carbon Neutral Basic Policy,” Japan Iron and Steel Federation, February 15, 2021
Outlook for Global Steel Production and Accumulation

- Demand for crude steel will increase
- Obsolete scrap will also increase, but not enough to meet steel demand
- Constant supply of pig iron is essential for supply of high-performance steel products


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Advantages and Problems of Current Steelmaking Process

Each method has advantages and disadvantages that require multi-track technological development.

### Blast furnace
- **Advantages**
  - Stable mass production
  - Can use existing equipment
  - Can use low and medium grade ore
  - Can manufacture high-grade steel
- **Disadvantages**
  - Requires replacement of coke and other materials with carbon-neutral reducing materials
  - Use of CCUS* is essential
  - Yet-unestablished method needed to prevent temperature drop in furnace during hydrogen reduction
  - Hydrogen cost is high

### Electric arc furnace
- **Advantages**
  - CO₂ emissions are low
  - Carbon neutrality once 100% hydrogen reduction is possible
- **Disadvantages**
  - Low productivity
  - Manufacturing high-grade steel is difficult
  - Scrap alone is insufficient iron source
  - Requires a carbon-neutral power source
  - High cost of electricity (Japan)

### Direct reduction
- **Advantages**
  - CO₂ emissions are low
- **Disadvantages**
  - Only high-grade ores can be used
  - New measures needed to prevent temperature drop in furnace during hydrogen reduction
  - Hydrogen cost is high
  - Capital investment cost is high

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*CCUS: Carbon Capture, Utilization and Storage*
**Roadmap to Carbon Neutrality in 2050**

- Accelerate research and development for early establishment of new technologies
- Adopt multi-track approach to develop super-innovative technologies, focusing on carbon recycling blast furnace + CCU and hydrogen ironmaking (direct reduction)
- Maximize utilization of industry-leading electric arc furnace technology

<table>
<thead>
<tr>
<th>CO₂ reduction targets</th>
<th>2020</th>
<th>2024</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transformation of steel-making processes</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Develop carbon-recycling blast furnace with CCU</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Devise processes and large-scale production in stages)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilize transition technologies for existing processes:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Ferro-coke, COURSE50, CCU, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maximize use of industry-leading electric arc furnace technology</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacture high-grade steel, introduce eco-friendly electric arc furnaces, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Develop hydrogen-based ironmaking (direct reduction)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

**Implementation**
- Assumes development of infrastructure for supplying large, inexpensive quantities of hydrogen and a system for sharing the costs throughout society

**Process Integration**
- Iron sources diversification

**Determine and announce revised targets for FY2030 under 7th medium-term period**

**Carbon neutrality by 2050**

**18% reduction compared to FY2013 (steel business)**

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02 Carbon-recycling Blast Furnace Technology Development
• To maximize the blast furnace method for mass, high-efficiency production, including for high-grade steel, technologies for reducing CO₂ emissions from blast furnaces are vital.

• Combining carbon-recycling blast furnaces with carbon dioxide capture, utilization and storage (CCUS) will enable steel works to recycle CO₂ while using raw materials of the same grade as those in conventional blast furnaces, thereby leading to net zero-carbon emissions.
Concept of Carbon-recycling Blast Furnace

**Carbon-recycling Blast Furnace**

- **CO₂**
- **Reuse of carbon** (Maximize benefits of carbon)
- **Blast furnace process**
- **Methanation**
- **Green hydrogen**
- **Methane** \((\text{CH}_4)\)
- \(\text{CO}_2\) from blast furnaces is converted into carbon-neutral reductant (methylene) by using hydrogen, thereby replacing coal-derived reductant

Reuse of carbon

(Maximize benefits of carbon)
Carbon-recycling Blast Furnace and Carbon Cycle (CCU*)

- Carbon recycling maximized in blast furnace to reduce CO₂ emissions
- CO₂ emissions minimized through society-wide carbon recycling of excess CO₂

Renewable energy, etc.  
Green hydrogen

Blast furnace
Carbon-recycling blast furnace

Separate CO₂

CO₂ CO H₂

Carbon recycling

Green hydrogen

Using surplus CO₂

Replace conventional petrol-based chemical products using CCU-produced methanol (see below**)

Convert excess CO₂ into basic chemicals (methanol, etc.)

Convert basic chemicals into chemical products** (synthetic resin, paints, etc.)

Recycle plastic containers, etc.

Process

Collect and transport

Waste plastic (useable in blast furnaces)

** Replace conventional petrol-based chemical products using CCU-produced methanol (see below)**

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• CO₂ generated from blast furnace is converted to methane and used repeatedly as reducing material.
• CO₂ emissions are reduced by replacing coke with carbon-neutral methane as the reducing material.

Blast furnace gas \[ \text{CO}_2 \text{ CO H}_2 \]

Effective utilization in CCUS

Carbon recycling

Methanation

O2

H2

H2O

CO2 CO H2

CH4 Carbon-neutral reductant

*Use of circulation gas

Methanation reaction
\[ \text{CO}_2 + 4\text{H}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O} \]

CO₂ reduction target of 30% in blast furnace, aiming at carbon neutrality through CCUS utilization
Overview of Methanation Technology

- Methanation: Technology for using green hydrogen to convert CO₂ (blast furnace exhaust gas) into methane (carbon-neutral reducing material)
- Key CCU technology expected to help realize carbon-neutral society

Methanation reaction:

\[ \text{CO}_2 + 4\text{H}_2 \rightarrow \text{CH}_4 + 2\text{H}_2\text{O} \]

*Shell and tube (S&T) reactors, plate reactors, etc.
An oxygen blast furnace can maximize the amount of methane blown in by heating carbon-neutral methane with combustion heat that conventionally is used to heat nitrogen gas.

Challenge: Need to develop an all-new technology to reduce CO₂ emissions by blowing in large amounts of carbon-neutral methane with oxygen. (world's first)

*Combustion heats gas to approx. 2,000°C to melt iron
Zeroing out nitrogen in blast furnace gas reduces amount of exhaust gas by about \( \frac{1}{2} \), and increasing CO\(_2\) concentration enables CO\(_2\) separation process to be downsized since less energy is required.

**Challenge**

**Interlock operation with large-scale methanation facilities** (world’s first)

- **Carbon recycling blast furnace (air blower)**
  - N\(_2\)
  - CO\(_2\) CO H\(_2\)
  - CH\(_4\)
  - Air (N\(_2\)+O\(_2\))
  - Methanation

- **Carbon recycling blast furnace (oxygen blower)**
  - CO\(_2\)
  - CO H\(_2\)
  - CH\(_4\)
  - H\(_2\)
  - CO\(_2\)
  - O\(_2\)
  - Miniaturization & less separation energy

Effective utilization in CCUS

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Application in carbon-recycling blast furnaces with CCU for CO₂ emissions reduction currently is jointly being developed by JFE and Research Institute of Innovative Technology for the Earth (RITE). New type of reactor for CCU methanol synthesis uses steel works exhaust gas to produce methanol significantly cheaper compared to conventional reactors.

**CCU Methanol Synthesis**

New-type reactor

H₂O selectively permeates separation membrane for greatly increased reaction rate

**Chemical equilibrium shifts to right (reaction acceleration)**

CO₂ + 3H₂ ⇌ CH₃OH + H₂O

Reactivity (%)

- **Conventional reactor**
  - Reactivity < 60%
- **New-type reactor**
  - Reactivity > 60% (No.1)
Roadmap for Developing Carbon-recycling Blast Furnace and Technology

Conduct elemental technology development and small-scale testing for both carbon-recycling blast furnaces and CCU methanol synthesis, targeting completion of proof-of-principle process by 2027

**Carbon-recycling blast furnace**

2020
- Element development
  - Partial technology test

2030
- Large-scale development
  - Implementation*

Small-scale demo (150m⁢³ scale in Chiba area)

CR blast-furnace elemental technology development: (1) Develop simulation model, (2) Design operations and facility (furnace shape, etc.) based on analysis of in-furnace phenomena (gas flow and temperature distribution), (3) Maximize combustion efficiency through pure oxygen methane burner combustion experiments

Partial demonstration of CR blast furnace: Conduct large-volume city gas injection test at Keihin No.2 blast furnace (before shutdown)

CCU elemental technologies development: (1) Develop low-cost CO₂ separation technology for CCU (2) Develop high-efficiency methanol synthesis reactor

**CCU methanol synthesis**

2020
- Element development
  - Basic design

2030
- Large-scale development
  - Implementation*

Small-scale demo

Elemental technology development: (1) Develop low-cost CO₂ separation technology for CCU (2) Develop high-efficiency methanol synthesis reactor

Basic design: (1) Conduct CO₂ separation lab tests to evaluate CO₂ separation efficiency and determine operation method (2) Conduct methanol synthesis lab tests to evaluate reaction rate and simulate reaction rate maximization

*Pursuant to development of infrastructure for cheap, high-volume hydrogen supply and system for sharing related costs throughout society

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Development of Technology for 100% Direct Hydrogen Reduction
Effectiveness of Hydrogen-reduction Technology

- Oxygen is removed from iron ore in a reduction furnace to produce reduced iron (Fe), which is then melted in an electric arc furnace.
- The amount of CO₂ generated with the current direct-reduction method is about 1/2 that of the blast furnace method.
- Using hydrogen during reduction and green electricity during melting produces zero CO₂ emissions.

**Direct-reduction process**

- **Reduction**
  - High-grade pellets (Fe₂O₃)
  - Gas for reduction (natural gas to hydrogen)
  - Reduced iron (Fe)

- **Melting**
  - Electricity (to green power)

**CO₂ emissions from various steel processes**

- **Blast furnace and converter method**
  - 2.0t-CO₂/t

- **Direct-reduction method (natural gas)**
  - 1.0〜1.5 t-CO₂/t

- **Direct-reduction method (green hydrogen & green electricity)**
  - Zero CO₂ emissions
Endothermic reaction inhibits reduction (Hydrogen reduction causes endothermic reaction)

Develop raw material preheating and hydrogen heating technology

- Develop raw material preheating technology
- Develop hydrogen heating technology

Reduction failure due to insufficient heat

Fe₂O₃ + H₂ → Fe + H₂O (Endothermic reaction)
Exothermic effect weakened by no ore reduction with CO
**Problems and Solutions for Hydrogen Reduction (2): Limited Raw Materials**

**Problem**
High-grade raw materials are produced in limited quantities and difficult to obtain.

**Solution**
Expand sourcing through collaboration with raw material supplier (BHP*)

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**Problem**
Currently, direct reduction can only use scarce high-grade raw materials, of which production is limited.

<table>
<thead>
<tr>
<th></th>
<th>Direct reduction</th>
<th>Blast furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality</td>
<td>High grade</td>
<td>Low to medium grade</td>
</tr>
<tr>
<td>Production (billion tons/year)</td>
<td>0.17</td>
<td>2.06</td>
</tr>
</tbody>
</table>

Low- and medium-grade raw materials are not used for direct iron reduction because they are difficult to pelletize and have low Fe content.

**Solution**
Develop processing technology for low- and mid-grade materials with BHP

Use as raw material for direct reduction

*One of three largest iron ore suppliers, mainly producing in Australia*
Development of Electric Arc Furnace Process Technology
Steel products are manufactured by melting steel scrap and direct-reduced iron in an electric arc furnace. The resulting CO₂ amount is about 1/4 that generated by the blast furnace-converter method. CO₂ emissions should be reducible to zero using hydrogen-reduced iron and green electricity.
**Problem**

Improve productivity of electric arc furnaces, currently 30% less than that of blast furnace-converters

Reduce electric power intensity

**Solution**

High-speed, high-efficiency melting technology for use in electric arc furnaces

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**Problem**

Productivity improvement

- 30% less Productivity

- 500 tons per unit per hour

- 300 tons per unit per hour* (top level globally)

**Solution**

- (1) Technology to melt scrap and reduce iron at high speed with less electric power

- (2) Technology for efficient melting

- ECOARC™ eco-friendly, high efficiency electric arc furnace (in use at JP Steel Plantech Co.)

- Continuous scrap charging in high-speed, high-efficiency melting furnace with high temperature exhaust gas preheating

- Need to further improve energy efficiency and productivity

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*Millennium Steel, Jumbo size 420t twin DC FastArc®EAF (2011)
Production of High-grade Steel in Electric Arc Furnace Process: Problem and Solution (2)

**Problem**
Quality constraints for products with electric arc furnaces (Many steel types are difficult to manufacture in terms of quality)

**Solution**
Technology to remove impurities and detoxify impurities

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**Problem**
Elimination of quality constraints

**Electric arc furnace process (scrap & reduced iron)**
Material degradation due to increased impurity concentration

- Many steel types hard to manufacture in electric arc furnaces
  - Vehicle steel sheets: Defects & poor processing performance
  - Electrical steel sheets: Deterioration of properties

**Solution**

1. (1) Technology to remove impurities
2. (2) Technology to detoxify impurities

- **Steel plates for cars**
- **Electrical steel sheet (motor cores)**

Technology for Using Scrap in Converters
Technology for Scrap Use in Converters

**Problem**
Need more robust melting technology to increase use of scrap in converters

**Solution**
(1) Design and engineer larger and more durable burners for use in large converters
(2) Utilize carbon-free fuels (hydrogen or carbon-recycled methane) to reduce CO₂ emissions

**Problem**
Increasing volume of scrap usage in a converter reduces heat

**Solution**
High-efficiency heat-transfer burner for melting scrap in converters

- Transferring combustion heat to iron using powdered material* heated with new burner
- JFE Steel’s “ONLY1” technology (already commercialized stainless-steel converters)
  Develop burner for normal steel converter

**Development Goals:**
(1) Design and engineer large burners
(2) Use carbon-free fuels such as hydrogen gas


Scrap ratio: 12-15% (current) → 20% or more (target)
Development of Process for Achieving Carbon Neutrality
Accelerate R&D for (1) blast furnace technology, (2) direct-reduction technology, (3) electric arc furnace technology and (4) conventional technology → Develop innovative technologies multilinearly, aiming to achieve carbon neutrality

**Blast furnace technology**
- Carbon-recycling blast furnace with CCU
- COURSE50 and Super-COURSE50
- Ferro coke

**Direct-reduction technology**
- Hydrogen-based ironmaking (direct reduction)
  - Measures for hydrogen endothermic reaction and restriction of raw materials

**Electric arc furnace technology**
- Electric arc furnace
  - Measures to improve productivity and lower electricity costs
  - Measures to manufacture high-grade steel
  - Measures to expand scrap (hard-to-use scrap, etc.)

**Conventional technology**
- Expanded use of scarp in converters, etc.
  - Development of high-efficiency, heat-transfer burner

**Green hydrogen, green electricity, & low-cost mass supply**

**Carbon neutrality**
Eco Products
(Electrical Steel Sheets Strategy)
Capture growing demand for high-grade electrical steel sheets both in Japan and overseas on group-wide basis.
**Eco-products: Strategy for Electrical Steel Sheets in Japan**

**Japan**

Expand manufacturing facilities for non-oriented electrical steel sheet (N/O)*

*Announced on April 1, 2021

**Increase capacity** of West Japan Works (Kurashiki district) to meet rising demand for high-grade non-oriented electrical steel sheets used in EV drive motors

**Total investment**

Approx. 49 billion yen

**Operation start**

First half of FY2024

**Production capacity**

Double current production capacity for high-grade non-oriented electrical steel sheets

**CO₂ reduction**

About 1.5Mt CO₂/year (due to increased adoption of electric vehicles)

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**Demand for high-grade non-oriented electrical steel sheets**, indispensable for electric automobiles, is expected to rapidly increase as global environmental regulations are accelerated/strengthened

**Europe**: Ban sales of gasoline vehicles
- 2025: Norway
- 2030: Germany, Netherlands & UK
- 2040: France

**Japan**: Promote electrification
- Shift to all electric vehicles
- Government: from 2035
- Tokyo: from 2030

**USA**: Convert to ZEVs and ban use of gasoline vehicles
- ZEV (EV, FCV, PHEV): 13 states have regulations
- California: Ban gasoline vehicles in 2035

**India**: Promote shift to EVs
- 100% by 2047

**China**: Shift to new energy vehicles and HEVs
- EVs, FCVs & PHEVs
- 2025: At least 20%
- 2030: At least 50%
- Convert gasoline vehicles to HEVs
- 2025: At least 50%
- 2030: 100%

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**Demand Forecast of high-grade non-oriented electrical steel sheets**

**Demand for High-Grade Non-Oriented Electrical Steel Sheets**

(Calculated by JFE; 2019 results = 1.0)

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Eco-Products: Overseas Strategy for Electrical Steel Sheets

MOU with JSW of India to study feasibility of electrical steel sheet JV*

Agreed with strategic-alliance-partner JSW to study establishing grain-oriented steel (G/O) manufacturing and sales company in India

*Announced on May 7, 2021

Demand Forecast of Grain-oriented Electrical Steel Sheets

The global demand for grain-oriented electrical steel sheets in transformers is expected to increase due to continuous growth in demand for electric power and the expanding adoption of renewable energy. The demand in India for grain-oriented electrical steel sheets is expected to increase by 1.7 times in 2030 compared to 2019 results.

Source: World Energy Outlook 2020, IEA

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Carbon Neutrality Initiatives in Engineering and Trading Businesses
Each company under the group

- **JFE Engineering**: Feasibility study of seabed-fixed foundation structure (monopiles) for an offshore wind power generation
  - SCM support
    - Steel supply

- **JFE Steel**: Increased production capacity and stable mass production of large and heavy plates for offshore wind power generation
  - Utilization of Kurashiki No. 7 Continuous Casting Machine in Kurashiki district (scheduled to start operation in FY2021)

- **JFE Shoji**: SCM construction for steel products and processed products for offshore wind power generation contributes to group collaboration
  - SCM Support

Each company under the group

- **JMU**: fabrication of offshore wind turbine floats and construction of work vessels
- **O&M**: operation and maintenance with maximum use of resources

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1. O&M: Operation & Maintenance. Applied repair and analysis techniques
2. JMU: Equity method affiliate Japan Marine United Corporation
Offshore wind power has been introduced mainly in Europe and China (24 GW as of 2018), but significant growth is expected in Asian countries (including Japan) and North America.

**Total installed offshore wind power (GW)**


**Estimated market expansion in Japan**

<table>
<thead>
<tr>
<th>Year</th>
<th>Expected power generation (GW)</th>
<th>Steel consumption (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2030</td>
<td>10</td>
<td>1.5</td>
</tr>
<tr>
<td>2040</td>
<td>30~</td>
<td>4.5~ 6.75</td>
</tr>
<tr>
<td></td>
<td><strong>Public and private sector adoption targets</strong></td>
<td></td>
</tr>
<tr>
<td>2050</td>
<td>90</td>
<td>13.5</td>
</tr>
</tbody>
</table>

**Trends in Japan’s monopile market**

From around 100,000 tons per year in FY2024, it is forecast to expand to 160,000 tons in the late 2020s and exceed 200,000 tons from the 2030s.

Note: Market size and steel consumption estimates based on ratio of foundation types per target installations.
**Study of monopile foundation-structure manufacturing**

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Establish monopile plant, first of its kind in Japan, deploying technologies for designing offshore structures, processing and welding large and heavy steel plates, and applying robust marine anticorrosion coatings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment scale</td>
<td>About 40 billion yen for plant buildings, machinery and equipment, wharf maintenance, etc.</td>
</tr>
<tr>
<td>Production period</td>
<td>Production targeted to start in April 2024 (corresponding to start of construction of Round 1 project)</td>
</tr>
<tr>
<td>Market share</td>
<td>50% share (target)</td>
</tr>
</tbody>
</table>

**Approx. size of main machine (12MW class)**

- **Transition pieces** (pipes connecting to wind turbine tower)
  - 9 to 11m in diameter
  - About 500t in weight

- **Monopiles** (super heavyweight)
  - Thick walls, large diameters & long length
  - 9 to 11m in diameter
  - About 1,400t in weight
Larger wind turbines to reduce power costs require larger foundation structures
⇒ Contribute to offshore wind power business with large, thick, high-quality cross-section plates manufactured from world top-class continuous-casting machine with large cross section

Investment in facilities for large and heavy plates for offshore wind

• High-efficiency casting of large cross-sectional slabs
• Advanced control technology for greatly improved slab surface and internal quality

Mass production of high-quality, large cross-section, large single-weight thick plates
Large-size plates for offshore wind: over 200k tons/year

Advantages of large-size plates in monopile manufacture

• Reduction of welding
• Reduction of assembly man-hours
• Shorter production lead time
• Increase in production volume

Less welds
Longer tube length

A tube for monopiles made with large-size plates
• Multiple welds
• Shorter tube length
**O&M Using Group Resources**

Lifecycle cost structure for seabed-fixed offshore wind turbines (European case: METI-Mitsubishi Research Institute data)

<table>
<thead>
<tr>
<th>Component</th>
<th>Cost Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>R&amp;D</td>
<td>2.9%</td>
</tr>
<tr>
<td>Manufacture of wind turbines</td>
<td>23.8%</td>
</tr>
<tr>
<td>Manufacture of foundation structure</td>
<td>6.7%</td>
</tr>
<tr>
<td>Electrical system</td>
<td>7.7%</td>
</tr>
<tr>
<td>Installation</td>
<td>15.5%</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>36.2%</td>
</tr>
<tr>
<td>Removal</td>
<td>7.2%</td>
</tr>
</tbody>
</table>

**O&M market size: around 2 trillion yen**
(Mitsubishi Research Institute data; based on Japan’s target of introducing 10 GW by 2030)

JFE aims to support the stable operation of wind turbine generators as a partner of generator manufacturers.

- **Power generation company**
- **Wind turbine generator**
- **BOP (Balance of plant)**

**External cooperation**
- **Windmill manufacturer**
- **JFE Group**
- **Partner company**

**Utilize know-how cultivated in onshore wind O&M and steel structure fabrication**

**Collaborate with other companies to support the stable operation of domestic offshore wind farms**

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## Contributions to CO₂ Reduction through Engineering Business

### Renewable Energy
- Diversify power sources (offshore wind & hydro)
- Participate widely in EPC and project management
- Provide energy services such as local supply of renewable energy sources and zero-emission plans for clients

**Renewable-energy business (EPC & projects)**
- Biomass, geothermal, solar, offshore wind power (through group synergies), etc.
- Waste power generation

### Carbon Recycling
- Conversion of CO₂ into synthesis gas and chemical products
- CO₂ separation and recovery

**Practical use of carbon recycling**

**CO₂-based chemical production technology**

<table>
<thead>
<tr>
<th>CO₂</th>
<th>Development process</th>
<th>Syngas</th>
<th>Raw materials of chemical products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste plastic</td>
<td>CO+H₂</td>
<td>Simultaneous achievement</td>
<td></td>
</tr>
</tbody>
</table>

- Carbon recycling of CO₂
- Chemical recycling of waste plastics

*Power producer and supplier that produces electricity locally for local consumption*
Support **local energy production for local consumption** (independent and decentralized) and **regional carbon neutrality** through biogas power generation from food waste and expansion of regional power producers and suppliers (PPS)*

- **Sapporo Biofood Recycling**
  - Feed & fertilizer production from food waste and biogas power generation
  - Food recycling and sales of locally produced electricity

- **Hachimantai city**
  - Hachimantai Geothermal Plant sales
  - Local electricity from Matsuo-Hachimantai Geothermal Power Plant

- **Tohoku Biofood Recycling**
  - Biogas power generation from food waste
  - Food recycling and sales of locally produced electricity

- **Tokorozawa city**
  - Tokorozawa Mirai Denryoku
  - Sales of locally produced electricity from waste power generation

- **Niigata city**
  - Niigata Swan Energy
  - Sales of locally produced electricity from waste power generation

- **Fukuyama city**
  - Fukuyama Mirai Energy
  - Sales of locally produced electricity from waste power generation

- **Kumamoto city**
  - Smart Energy Kumamoto
  - Sales of locally produced electricity from waste power generation

- **Toyohashi city**
  - Honokuni Toyohashi Electric Power
  - Sales of locally produced electricity from biogas power generation

- **J Biofood Recycling**
  - Biogas power generation from food waste
  - Food recycling and sales of locally produced electricity

*Produce electricity locally for local consumption
Leverage global network and corporate resources for carbon neutrality within JFE group and society.

**JFE Shoji**

- **JFE Steel**
  - Reduce CO₂ emissions in steel business
  - Collaborate with JFE Steel to expand steel scrap procurement and explore procurements of reduced iron and later hydrogen

- **JFE Engineering**
  - Facilitate wider use of renewable energy
  - Support the stable supply of fuel for biomass power plants operated by JFE Engineering to help reduce CO₂ emissions

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**Aim to become carbon neutrality**
04 Carbon Neutrality Proposals to Society
JFE’s key business concern is developing carbon-neutral steelmaking, but many other issues also must be resolved.

Costs of Achieving Carbon-neutral Steel

- **Massive research and development costs**
  - Approximately 100 billion yen by 2030 and more by 2050 (will require maximum use of government R&D support, such as Green Innovation Fund)

- **Massive investment in equipment**
  - Total capital investment in steel works will exceed R&D costs (approximately 500 billion yen per blast furnace with a capacity of 4 million tons per year)

- **Stable supply of inexpensive, high-volume green hydrogen and electricity, and development of related infrastructure (Ensure the global competitiveness of industrial power price)**

- **Even with cheap hydrogen, production costs will significantly increase***

*Assuming 20 yen per Nm³ of hydrogen

Significant cost increases are inevitable and there are limits to the efforts of individual companies. Government support and cooperation with society will be essential, including for the creation of a mechanism through which society would bear the increased costs.
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