Status of Sustainability-oriented Business Development

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Overview
Overview

Group environmental initiatives

- Construction of plants and facilities that contribute to lower environmental impact
- Functional materials manufacturing for low-carbon and environmental purposes
- Commercialization of environmental technologies
Group-wide promotion of commercialization
Overview

Co-creation with other companies

Also applying other companies' technologies to build value chains and create new business

External partners
- Companies in Japan and overseas
- Joint ventures
- Universities, research institutes
- Government agencies, municipalities

[Diagram showing co-creation process with sections for expertise, technology, consulting, licensing, manufacturing, facility maintenance, and design and construction of production facilities]
Overview

Fields of interest

Recycling
- Waste plastic recycling
- Sustainable aviation fuel (SAF)

CO2 emission control and utilization
- Carbon dioxide capture and storage (CCS)
- DDR membranes
- CO2 mineralization

New energy
- Hydrogen (ammonia)

Other fields of interest
- Bio
- Energy management
- Green chemicals, etc.
Recycling initiatives
Overview

• The Ebara Ube Process (EUP) was developed by Ebara Environmental Plant Co., Ltd. and Ube Industries, Ltd. Plastic waste is gasified with oxygen and steam to produce syngas for use in synthesis of chemical products.

• Waste plastic gasification technique with the world’s only long-term track record of commercial operation, at the Kawasaki Plant of Showa Denko.

• Relicensing agreement concluded in October 2020. Toward further use of EUP, we will promote licensing and facility construction.

Competitive advantages

• One of the few processes that can break down, at the molecular level, mixed plastic waste and plastic with impurities, which are physically difficult to recycle.

• Supports production of a broad range of products such as hydrogen, ammonia, and propylene.

Market scale

Projected total global amount of plastic for chemical recycling

2020: tens of thousands of tons/year ⇒ 2030: nearly 50 million tons/year

Source: How plastics waste recycling could transform the chemical industry, McKinsey & Company
Overview

- We are accelerating the establishment of both a system to produce domestic SAF as a next-gen aviation fuel from hydrogenated waste cooking oil and the corresponding value chain.
- We are evaluating business feasibility in fiscal 2020 toward operation of production facilities and full-scale commercialization around 2025.
- Meanwhile, we are also involved in producing SAF from waste plastic.

Strategy

- Early commercialization at scale; enjoy first-mover advantage

Participant strengths and roles

- Network that recovers used cooking oil
- Expertise in biodiesel production
- Proposal and construction of economical production facilities, applying an extensive track record in plant construction
- Wealth of experience in sales and supply of energy products and operation of related facilities

Market scale

Projected SAF demand in Japan

2020: 0 L/year ⇒ 2030: nearly 340,000 kL/year

(JGC estimate, assuming introduction of SAF that has the effect of reducing CO₂ by 70%, and with SAF contributing half of the required amount of CO₂ reduction relative to the required amount of international flight refueling in Japan.)
03 CO₂ emission control and utilization initiatives
CO₂ emission control and utilization

Building on array of supporting technologies and past achievements

- HiPACT® chemical absorption method
  - CO₂ separation using DDR-type zeolite membranes
  - Source: Naftna Industrija Srbije (NIS)

- Resource recovery

- Sequestration

- Direct use

- CO₂ mineralization

- CCS (underground CO₂ storage)

- CO₂-EOR Enhanced Oil Recovery
## JGC CCS achievements

<table>
<thead>
<tr>
<th>Client</th>
<th>Country</th>
<th>Plant</th>
<th>Completed</th>
<th>Highlights</th>
</tr>
</thead>
<tbody>
<tr>
<td>BP Exploration (In Salah) Ltd./Sonatrach</td>
<td>Algeria</td>
<td>Natural gas processing</td>
<td>2004</td>
<td>World’s 2\textsuperscript{nd} CCS plant at a natural gas processing site</td>
</tr>
<tr>
<td>Gorgon JV</td>
<td>Australia</td>
<td>LNG plant</td>
<td>Not disclosed</td>
<td>One of the world’s largest CCS projects</td>
</tr>
<tr>
<td>Naftna Industrija Srbije (NIS)</td>
<td>Serbia</td>
<td>Natural gas processing</td>
<td>2015</td>
<td>Applies HiPACT\textsuperscript{®} co-developed with BASF (licensed)</td>
</tr>
<tr>
<td>Japan CCS Co., Ltd.</td>
<td>Tomakomai, Hokkaido</td>
<td>Oil refinery (hydrogen production facility)</td>
<td>2016</td>
<td>First large-scale CCS in Japan</td>
</tr>
</tbody>
</table>
Overview

- Original CO₂ separation technology applying DDR-type zeolite membranes has been developed with NGK Insulators.
- Large-scale field testing has been underway in U.S. since 2020. We are planning to apply this at commercial plants after testing.

Strategy

- Higher CO₂/CH₄ selectivity compared with conventional polymeric membranes, promising in CO₂-EOR (enhanced oil recovery) by high operation durability in high-pressure and high CO₂ concentration.

Market scale

U.S. CO₂-EOR demand forecast

2020: Approx. 500,000 barrels/day ⇒ 2030: Approx. 1.4 million barrels/day  
(Source: US Department of Energy "Carbon Capture, Utilization, and Storage: Climate Change, Economic Competitiveness, and Energy Security")
Overview

- Method of extracting calcium and magnesium from waste materials (such as waste concrete and seawater/waste brine*) and combining it in a reaction with CO₂ from thermal power plants or the like to produce carbonates.
- Carbonates are a useful raw material in industrial products and also serve as a construction material.

*Waste brine: Desalination wastewater that is twice as concentrated as seawater. Highly saline.

Current initiatives: Two NEDO-commissioned projects

- Development of an accelerated carbonatization process using calcium and the like in industrial waste, such as waste concrete
- Development of CO₂ fixation technique using seawater and waste brine that also produces valuable resources
New energy initiatives
New energy initiatives
Hydrogen (ammonia)

Compatible with all hydrogen carriers. Ammonia is a significant forte of ours.

### Comparison of main hydrogen carriers

<table>
<thead>
<tr>
<th>Carrier</th>
<th>Advantages</th>
<th>Issues</th>
<th>JGC Technologies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid hydrogen</td>
<td>• Pure hydrogen (100%)</td>
<td>• Extremely low temperature of -253°C makes it difficult to be handled</td>
<td>• Cryogenic technology applying expertise with LNG</td>
</tr>
<tr>
<td>LOHC (organic hydride)</td>
<td>• Can be stored/transported at normal pressure and temperature; easy to handle</td>
<td>• Low hydrogen density (47.3 kg-H2/m3 for MCH)</td>
<td>• Hydrogenation/dehydrogenation processing technology</td>
</tr>
<tr>
<td>Ammonia</td>
<td>• Highest hydrogen density (121 kg-H2/m3)</td>
<td>• Hazardous; must be handled with care</td>
<td>• Green ammonia synthesis process</td>
</tr>
<tr>
<td></td>
<td>• Can be combustible directly without CO₂ emissions</td>
<td></td>
<td>• New ammonia synthesis catalysts</td>
</tr>
<tr>
<td></td>
<td>• Large commercial supply chain already established</td>
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</tbody>
</table>
New energy initiatives

Ammonia

Overview

• Hydrogen as ammonia can be transported and stored efficiently; supply chain has already been established
• Can be used directly in power generation, marine engine or other applications; no CO₂ emissions from combustion
• Determined to be an optimal hydrogen carrier for mass consumption and transportation

Market scale

Projected fuel ammonia demand in Japan
2020: 0 tons/year ⇒ 2030: Approx. 3–5 million tons/year

Source: Ammonia Roadmap, Clean Fuel Ammonia Association

Competitive advantages

• World’s first successful demonstration of a green ammonia value chain – with hydrogen from solar-powered water electrolysis, ammonia synthesis at low temperature and pressure, and power generation by an ammonia gas turbine (47 kW)
• Participated in a blue ammonia pilot program that produces ammonia from fossil fuels and offsets CO₂ with CCS; have knowledge and technology in both green and blue applications
• Have received FS/FEED inquiries for multiple hydrogen and ammonia production projects in Japan and overseas

Technology developed: Low pressure (< 80 barA)
(Conventional technology: High pressure (200 barA))

Developed a new ammonia synthesis catalyst that is highly active at low temperature and pressure; greatly reduces the energy needed
Future policies
Future policies

Key areas: waste plastic gasification and hydrogen (ammonia)

Accelerate efforts to create new business

• Focus on securing FEED and EPC orders for waste plastic gasification chemical recycling and hydrogen (ammonia) projects that we expect to lead to new business at an early stage.

• Propose plans to clients that combine CO2 separation and capture technology with the existing LNG supply chain, and aim to secure orders for FEED and EPC in related projects.

Find and nurture the seeds of future environmental business

• As seeds of new business besides waste plastic gasification, hydrogen (ammonia), and CCS, promptly implement technical development, verification, and business feasibility evaluation for CO2 mineralization, next-gen aviation fuel (SAF), and DDR-type zeolite membranes, among others.

• Also sow seeds for other business such as bio, electricity management, and green chemicals.

• Venture into certification, LCA, and trading in preparation for the introduction of carbon pricing.