Status of Sustainability-oriented Business Development

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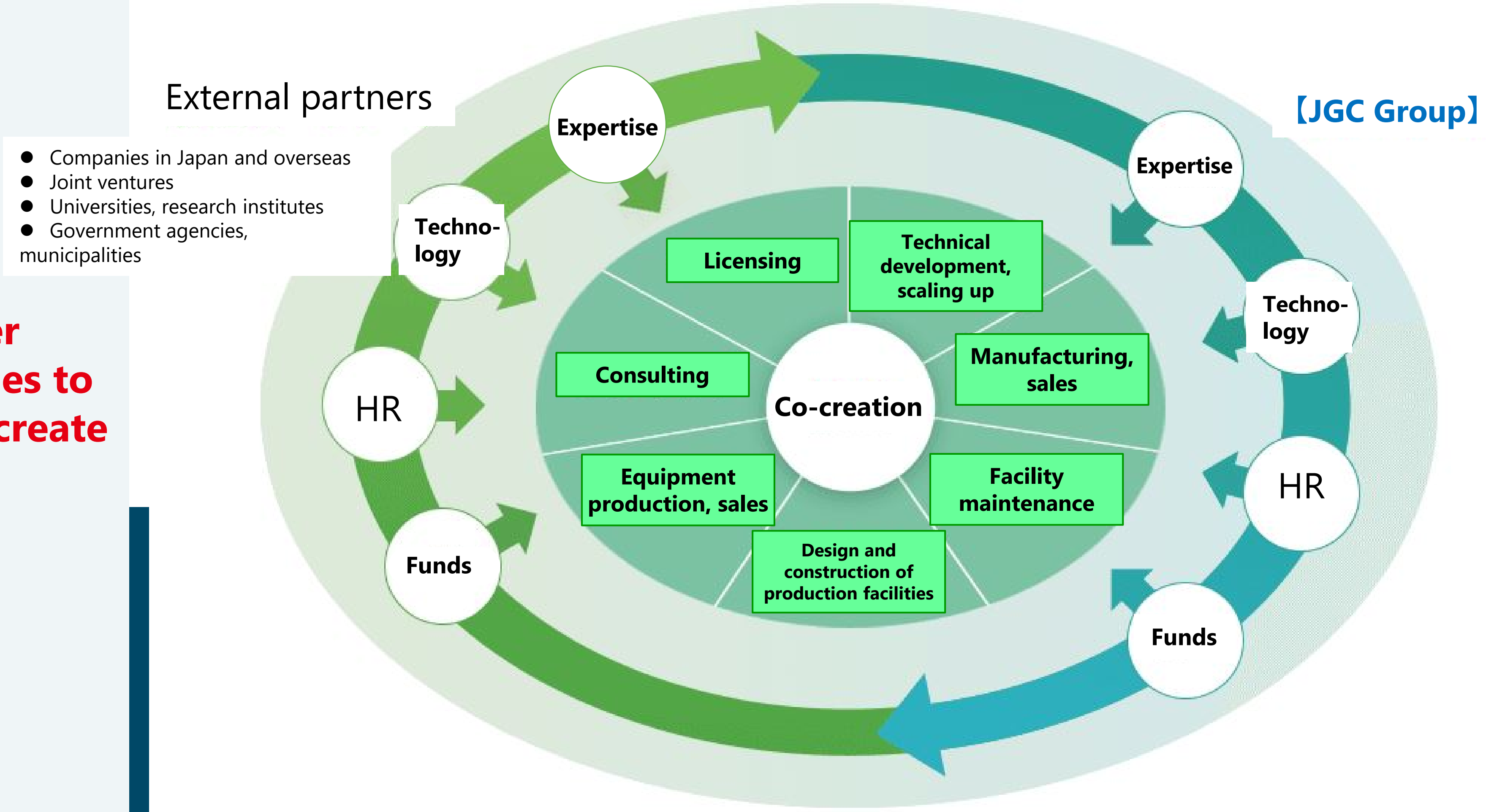
Framework

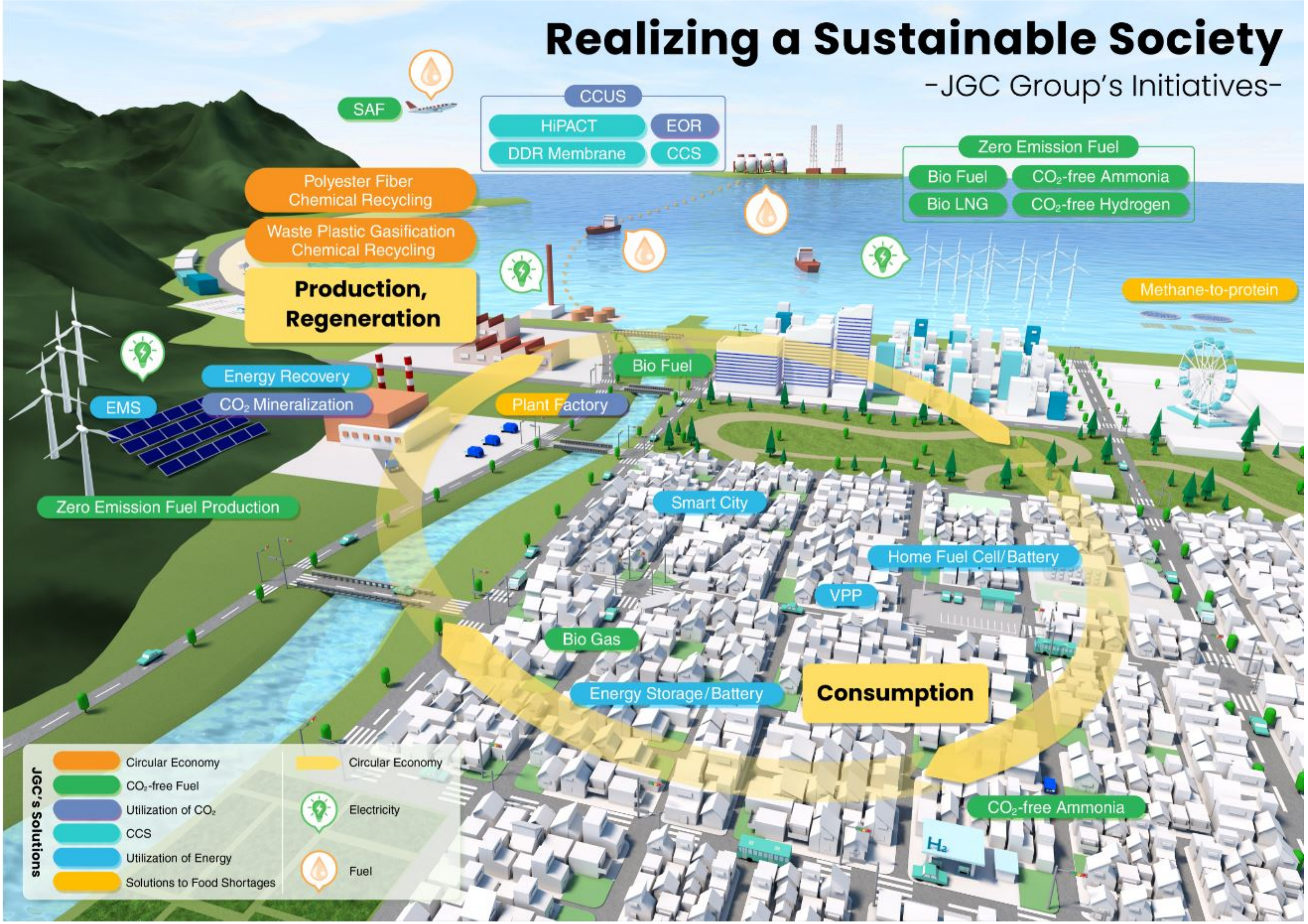
Group-wide promotion of commercialization

Co-creation with other companies

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



Fields of interest



Recycling

- Waste plastic recycling
- Sustainable aviation fuel (SAF)

CO_2 emission control and utilization

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

New energy

- Hydrogen (ammonia)

TM

Other fields of interest

- Bio
- Energy management
- Green chemicals, etc.

02 Recycling initiatives

Waste plastic gasification chemical recycling

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

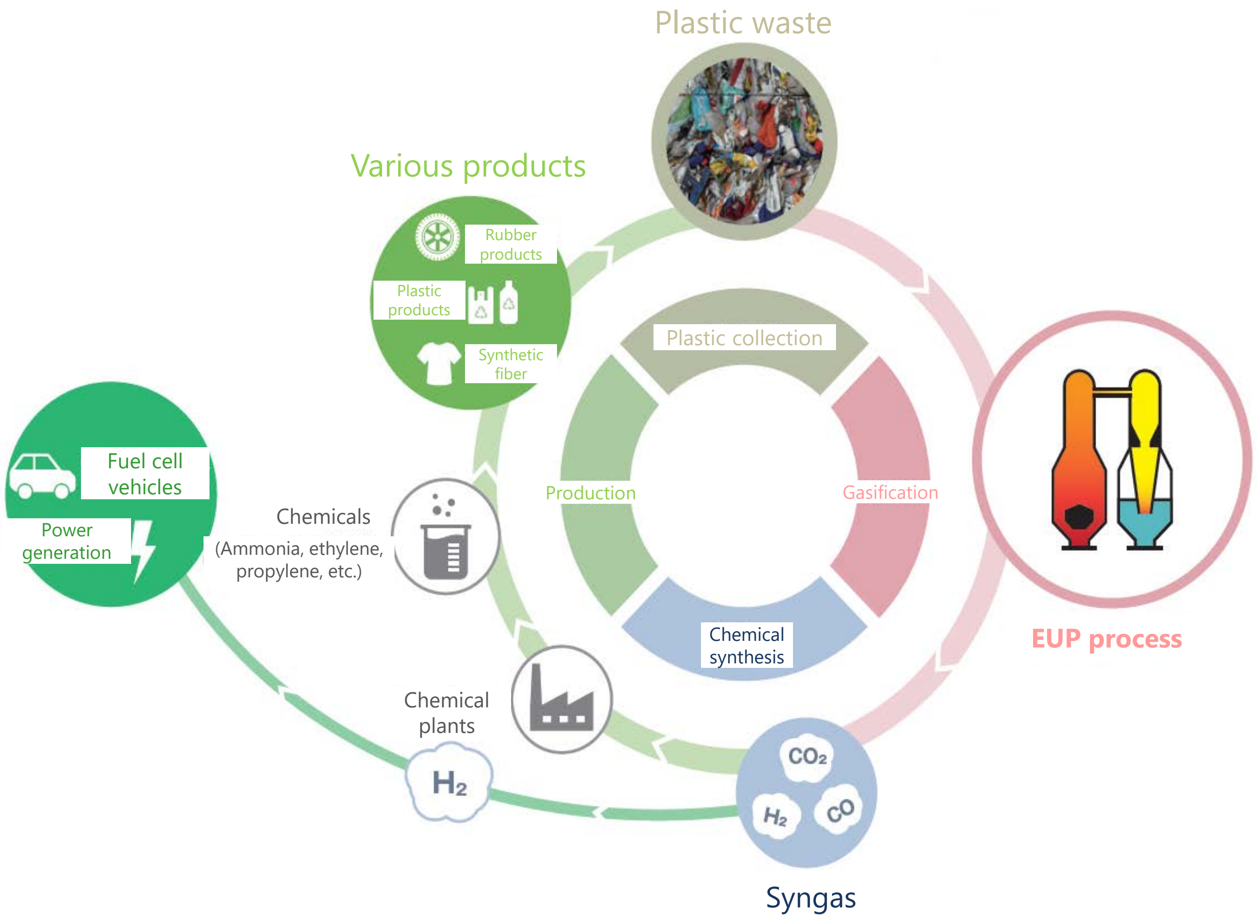
- One of the few processes that can break down, at the molecular level, mixed plastic waste and plastic with impurities, which are physically difficult to recycle.
- Supports production of a broad range of products such as hydrogen, ammonia, and propylene.

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



Production of sustainable aviation fuel

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

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 CO_2 by 70%, and with SAF contributing half of the required amount of CO_2 reduction relative to the required amount of international flight refueling in Japan.)

Participant strengths and roles

REVO INTERNATIONAL

- Network that recovers used cooking oil
- Expertise in biodiesel production

JGC

- Proposal and construction of economical production facilities, applying an extensive track record in plant construction

JAPEX

- Wealth of experience in sales and supply of energy products and operation of related facilities

03

CO_2 emission control and utilization initiatives

CO_2 emission control and utilization

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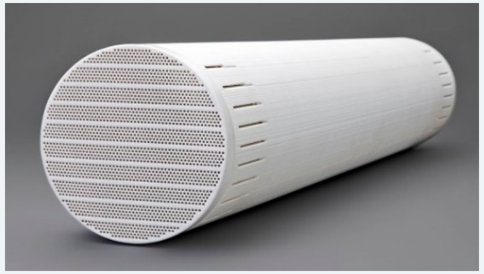
Building on array of supporting technologies and past achievements

Separation, recovery

HiPACT® chemical absorption method

Source: Naftna Industrija Srbije (NIS)

CO_2 separation using DDR-type zeolite membranes



Resource recovery

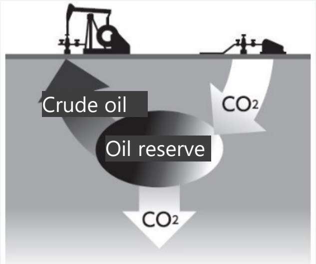
CO_2 mineralization

Sequestration

CCS

(underground CO_2 storage)

Direct use



CO_2-EOR Enhanced Oil Recovery

Carbon dioxide capture and storage (CCS)

JGC CCS achievements

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

In Salah natural gas plant


Gorgon LNG plant


Tomakomai CCS facilities

Carbon capture and recovery using DDR-type zeolite membrane

Overview

- Original CO_2 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.

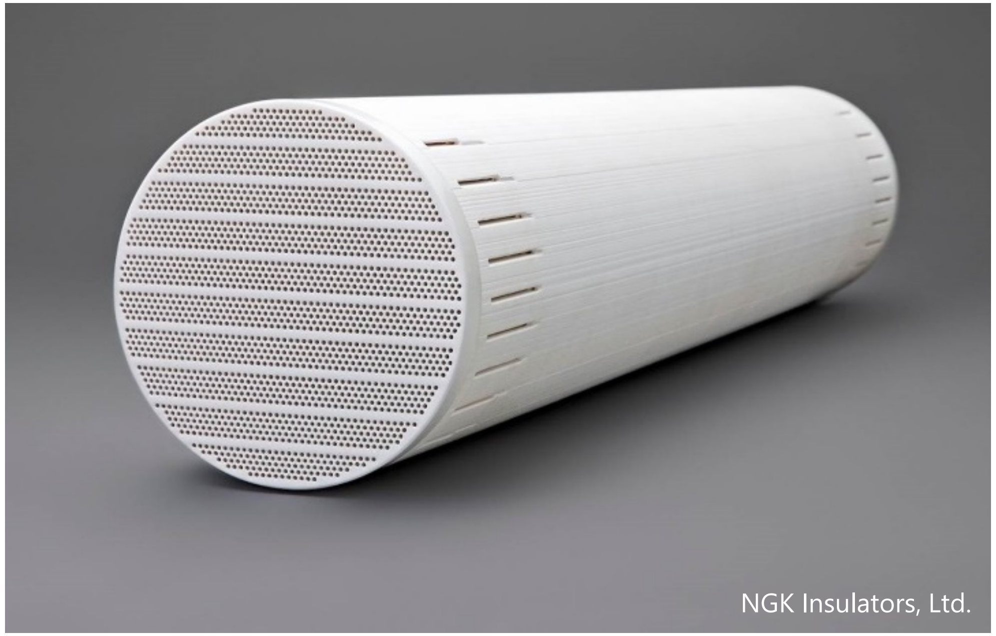
Strategy

- Higher CO_2/CH_4 selectivity compared with conventional polymeric membranes, promising in CO_2-EOR (enhanced oil recovery) by high operation durability in high-pressure and high CO_2 concentration.

Market scale

U.S. CO_2-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"



DDR-type zeolite membrane

CO_2 mineralization

JGC

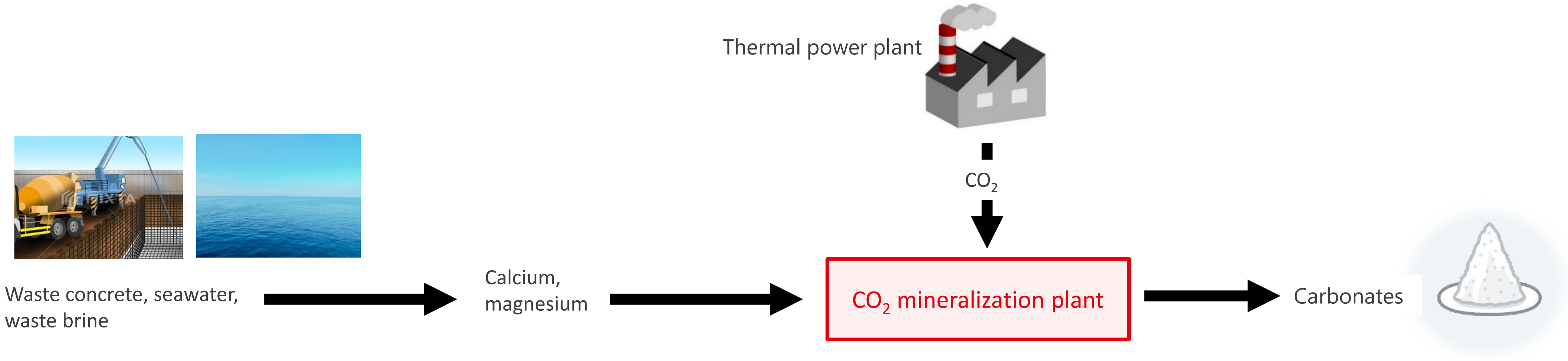
Overview

- Method of extracting calcium and magnesium from waste materials (such as waste concrete and seawater/waste brine*) and combining it in a reaction with CO_2 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 CO_2 fixation technique using seawater and waste brine that also produces valuable resources



04 New energy initiatives

Hydrogen (ammonia)

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

Comparison of main hydrogen carriers

Carrier	Advantages	Issues	JGC Technologies
Liquid hydrogen	• Pure hydrogen (100%)	• Extremely low temperature of -253°C makes it difficult to be handled	• Cryogenic technology applying expertise with LNG
LOHC (organic hydride)	• Can be stored/transported at normal pressure and temperature; easy to handle	• Low hydrogen density (47.3 kg-H2/m3 for MCH)	• Hydrogenation/dehydrogenation processing technology
Ammonia	• Highest hydrogen density (121 kg-H2/m3) • Can be combustible directly without CO_2 emissions • Large commercial supply chain already established	• Hazardous; must be handled with care	• Green ammonia synthesis process • New ammonia synthesis catalysts AMUSE™ Zero Emission Fuel

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 CO_2 emissions from combustion
- Determined to be an optimal hydrogen carrier for mass consumption and transportation

Market scale

Projected fuel ammonia demand in Japan

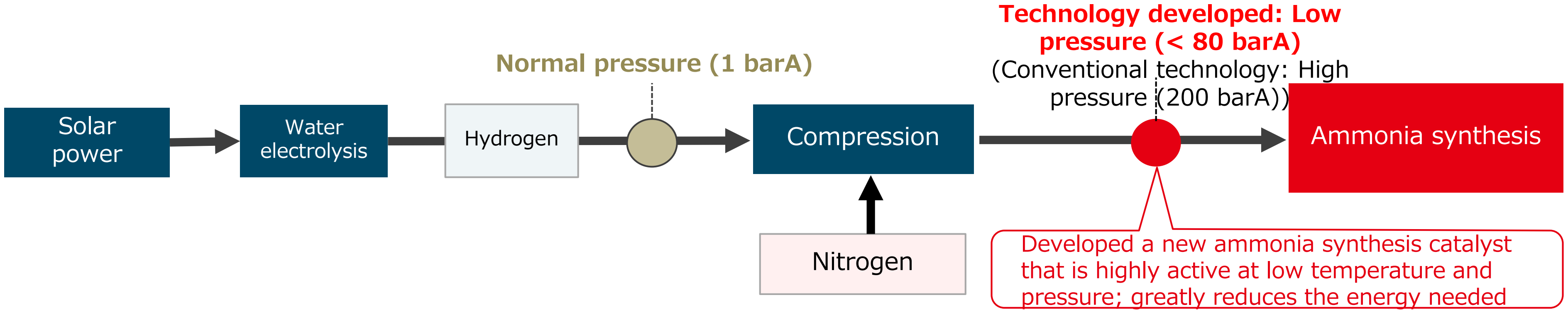
2020: 0 tons/year ⇒ 2030: Approx. 3–5 million tons/year

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 CO_2 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

Ammonia synthesis pilot project facility



05 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 CO_2 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 CO_2 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.