



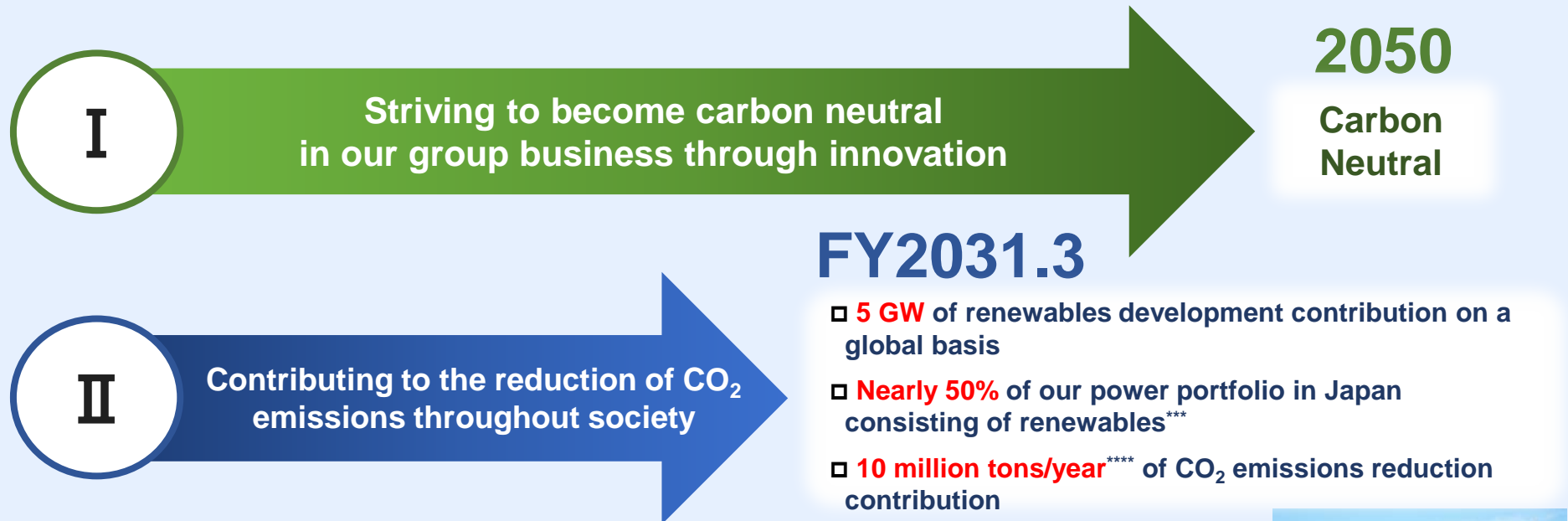
# Daigas Group Carbon Neutral Vision

January 2021  
**Osaka Gas Co., Ltd.**

# 01 Striving to become carbon neutral by 2050

We strive to become carbon neutral by 2050 through decarbonization of our gas and electricity by introducing methanation\* to generate gas with renewable energy and hydrogen and by increasing the share of renewables in our power generation portfolio. And as an innovative energy and services company, we plan to provide solutions for the realization of a sustainable society.

While technologies are being developed to realize a carbon neutral society, we also strive to contribute to radical reduction of CO<sub>2</sub> emissions by promoting advanced utilization of natural gas and wider usage of renewable energy, aiming for a CO<sub>2</sub> emissions reduction contribution target of more than 8.5 million tons/year\*\*, which was previously set for 2030.



\* Methane generation technology using hydrogen and CO<sub>2</sub>

\*\* Our CO<sub>2</sub> emissions reduction contribution annual target for 2030 set out in our long-term management vision announced in 2017 (2030 cumulative target: 70 million tons)

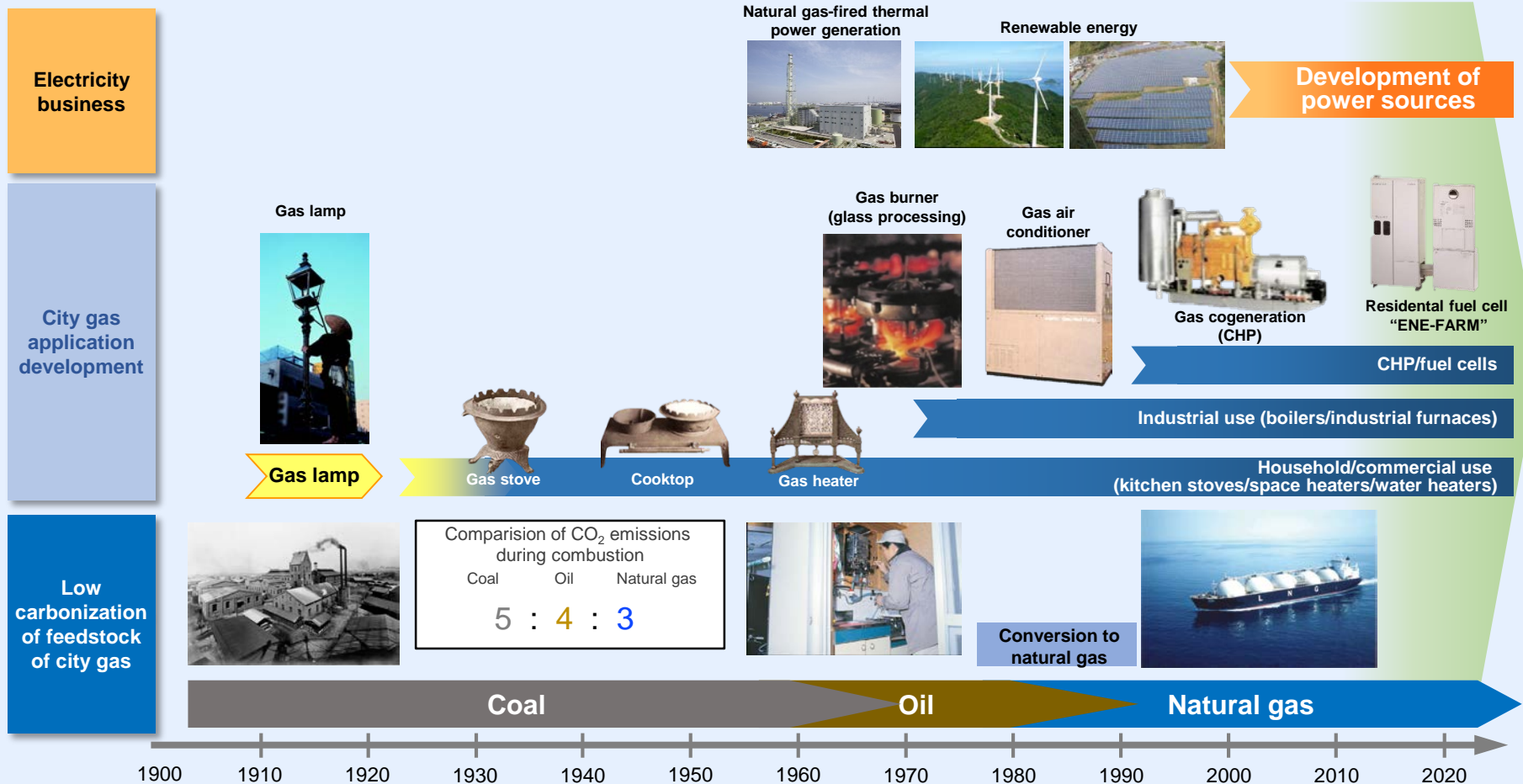
\*\*\* Including solar, wind, and biomass power projects, which are eligible for the feed-in tariff (FIT) scheme

\*\*\*\* Equivalent to one third of the CO<sub>2</sub> emissions currently produced in our business and by our customers (33 million tons/year)



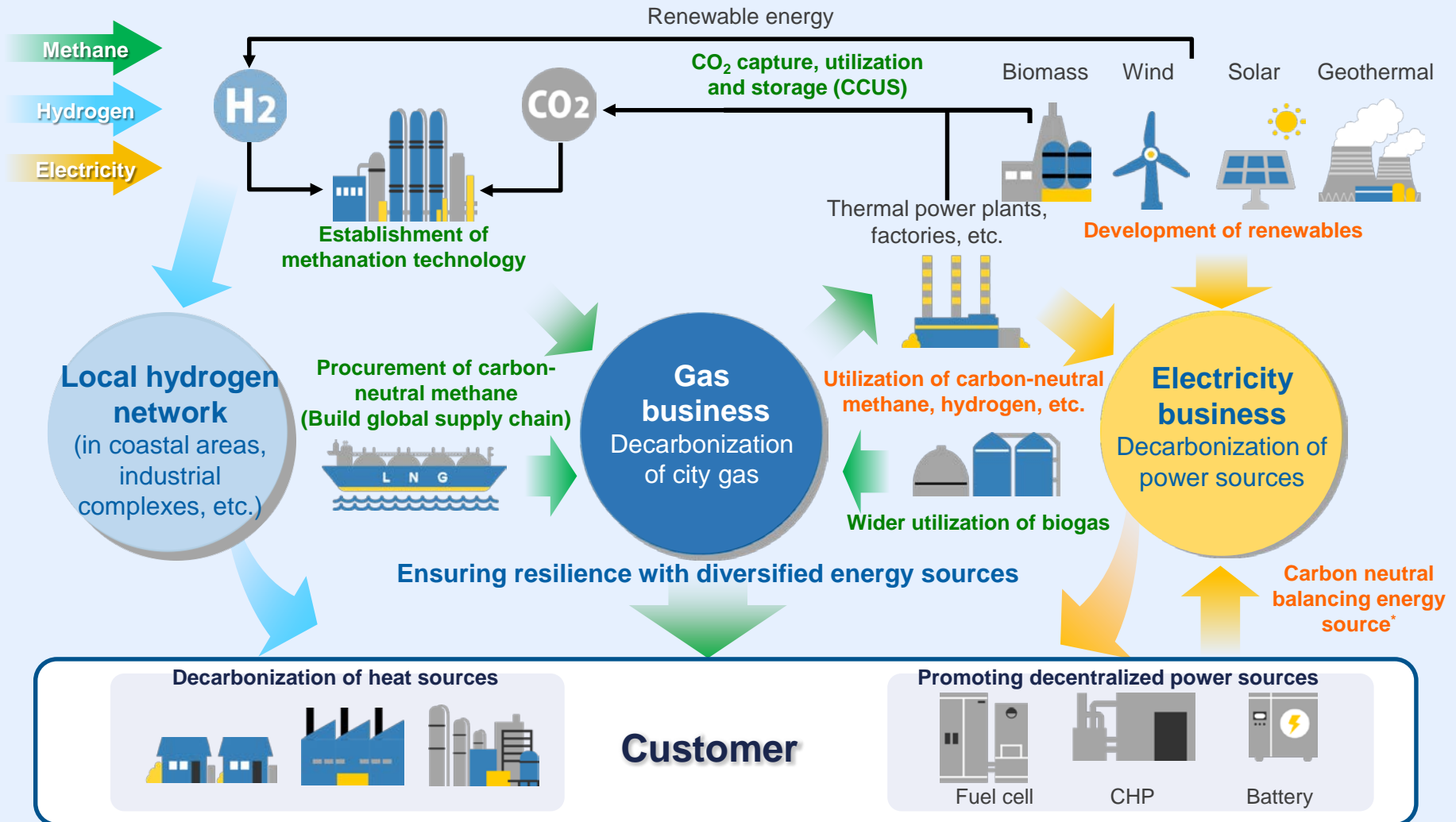
# 02 Innovations in our business

Since the commencement of our operations in 1905, we have been developing new products and services to meet the needs of customers and society. With our pipeline gas supplies switched from coal gas to oil gas and then to natural gas, we have been developing gas appliances for our industrial customers to change the fuels they use from coal and oil to natural gas. In the early days of our business, we replaced oil lamps with gas lamps. Subsequently, we introduced natural gas to kitchen stoves, space heaters, and water heaters. In recent years, we have developed advanced appliances such as gas cogeneration systems and fuel cells, thereby contributing to energy conservation and low carbonization at our customers' premises. In 2000, we entered the electricity business, and since then have constructed natural gas-fired thermal power plants and developed renewable energy sources.



# 03 Our energy business in the era of carbon neutrality

How to achieve carbon neutrality should be flexibly selected in light of progress in energy innovation and changes in social circumstances. We aim to achieve our carbon neutrality goal with a comprehensive approach throughout our supply chain including customers, taking into account future technological advances and economic rationality.

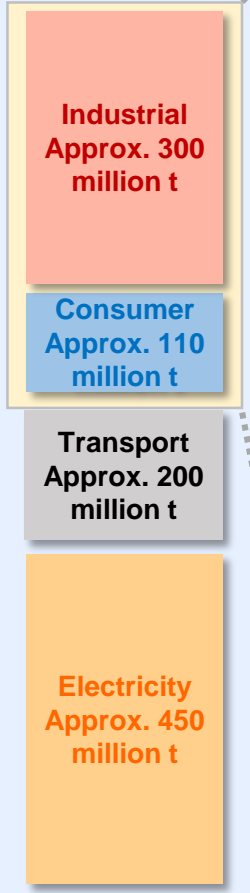


\*contributing to balancing the intermittency of renewables

# 04 Heat-based contributions to low carbonization/decarbonization

In the industrial sector that uses coal and oil for technological and economic reasons to generate high-temperature heat, we are promoting CO<sub>2</sub> emissions reduction and carbon neutrality through the fuel conversion to natural gas and, in the future, carbon-neutral methane.

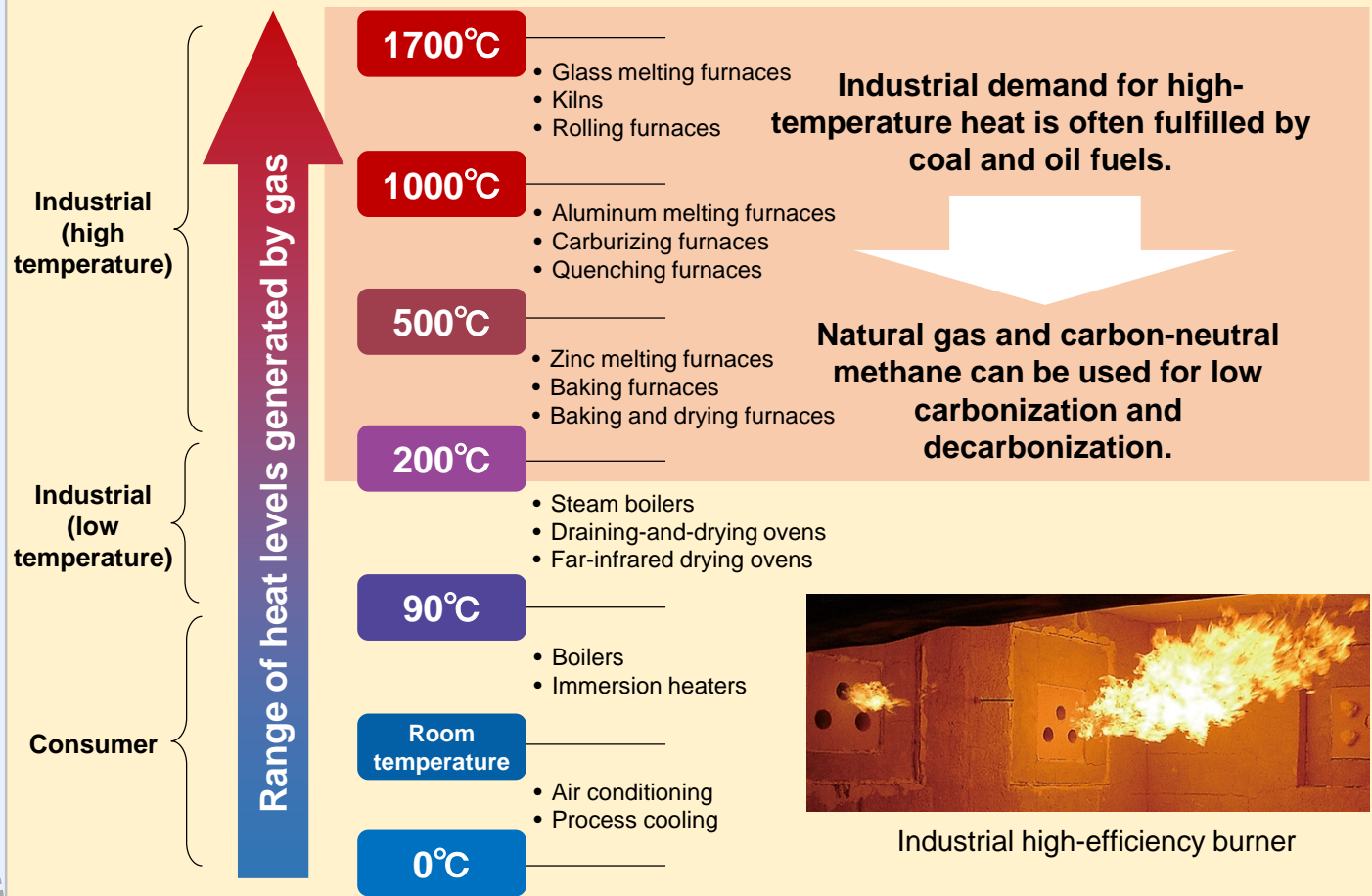
Annual CO<sub>2</sub> emissions  
**Approx. 1,060 million t**



2018

Source: Created from material released by the Strategic Policy Committee and the Hydrogen and Fuel Cell Strategy Council of the Ministry of Economy, Trade and Industry

### <Principal Applications>



# 05 Gas-based energy systems highly compatible with renewables

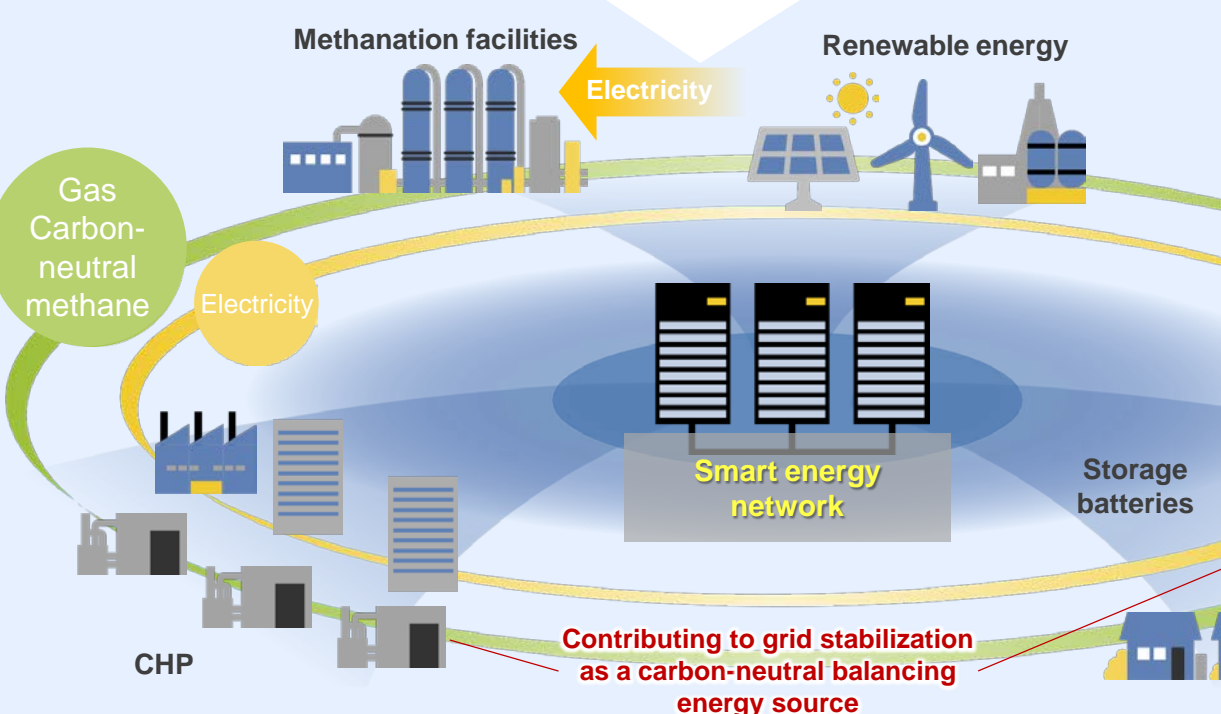
As renewables are subject to weather conditions, it is important to achieve the best mix between them and decentralized power sources such as CHP and fuel cells that can balance the intermittency of renewables.

We are building virtual power plants (VPP) with decentralized power sources aggregated using digital technology to contribute to grid stabilization and further energy conservation.

We are building a **smart energy network** that monitors and controls a group of decentralized power sources (CHP and renewable energy power sources), which will contribute to grid stabilization as a **carbon-neutral balancing energy source**.

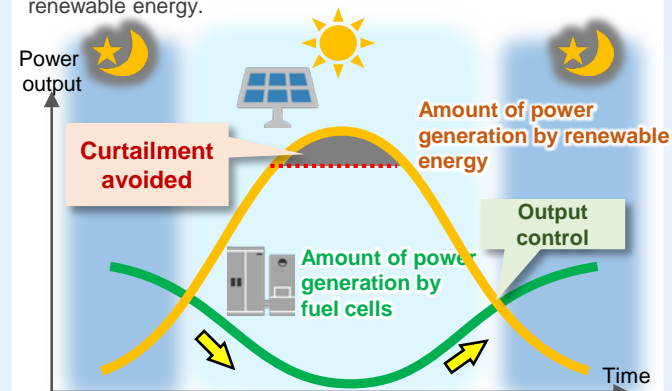
### <Solution to long-term variations in power output>

Renewable energy is subject to seasonal and other variations in power output. Methanation makes efficient use of excess power from renewable energy (power to gas).



### <Solution to short-term variations in power output>

The system controls the power output from household fuel cells according to the cyclic power generation patterns of renewable energy sources for grid stabilization and increasing use of renewable energy.

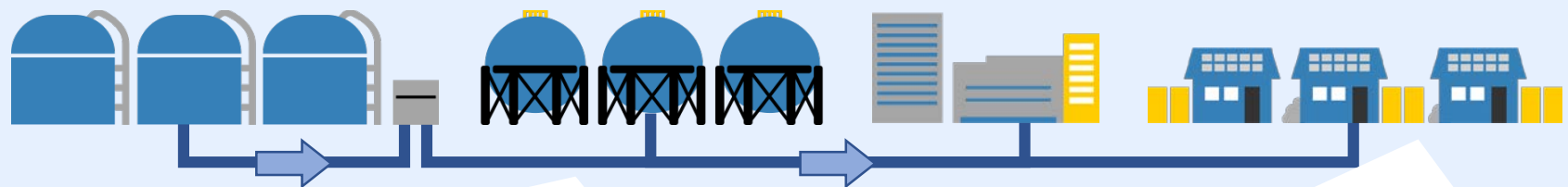


### <Participation in VPP Aggregator Demonstration Project>

We participate in the VPP Aggregator Demonstration Project organized by the Ministry of Economy, Trade and Industry. Its demonstration experiment is underway, utilizing approximately 1,500 fuel cell units.

# 06 Enhancing energy resilience

We are committed to contributing to energy resilience enhancement with diverse energy sources as a vital task. This serves as an energy security solution against the risk of increasing natural disasters resulting from climate change and the uncertainty over future technological development to achieve a carbon-neutral society. As one of the diverse energy sources, gas is expected to continue playing an important role.



## Resilience of city gas infrastructure

### 2018 Northern Osaka Earthquake - damage and response

Size of earthquake	Seismic intensity: 6-; Magnitude: 6.1
Damage to the Medium pressure (commercial/industrial uses)	No suspension of service
Damage to the Low pressure (residential use)	Suspension of service to approx. 110,000 households ⇒ Restoration completed within one week



2018 Northern Osaka Earthquake\*



Quake-resistant polyethylene pipe

\* Courtesy of The Mainichi Newspapers

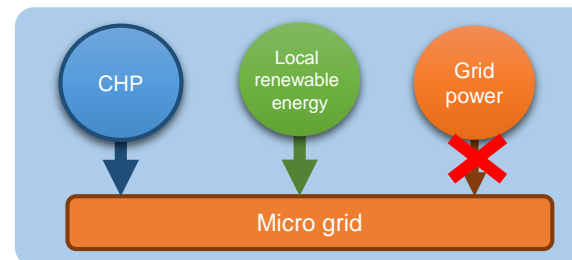
## Resilience of decentralized power sources

During the outage occurred by Typhoon Jebi in 2018, power outage-resistant fuel cells supplied electricity and heat.



Used to supply electricity and hot water during power outages

Local renewable energy power sources and CHP are used for local production for local consumption of power. In the event of a power outage, a micro grid is used for continuous power supply to local consumers.

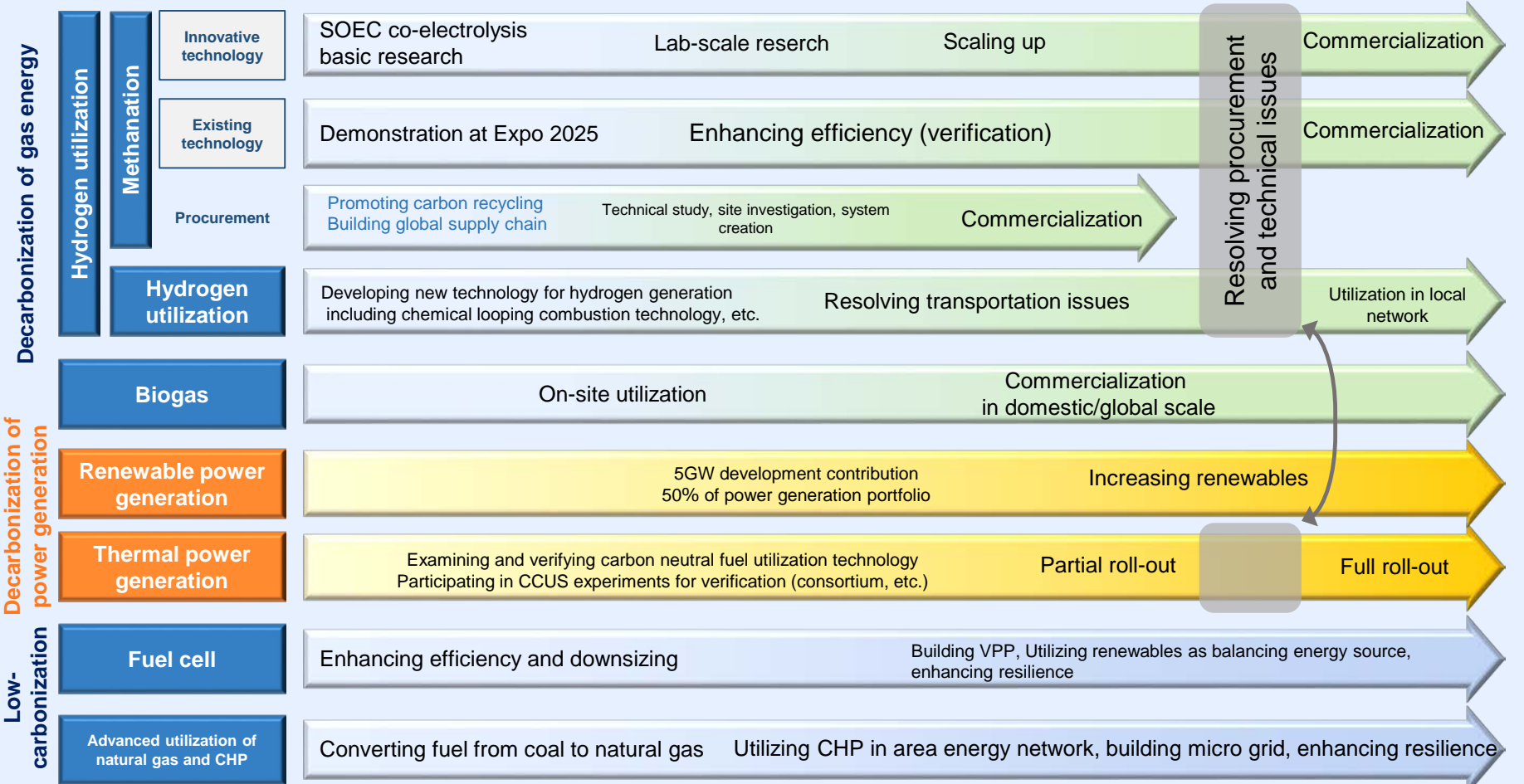


# Road Map to Carbon Neutrality

We aim to achieve our carbon neutrality goal through our ongoing initiatives including methanation R&D and renewable power generation capacity development and other activities as shown in the road map below.



\*subject to reviews in accordance with government policy changes and technological advancement  
 \*including utilization of imported carbon-neutral LNG





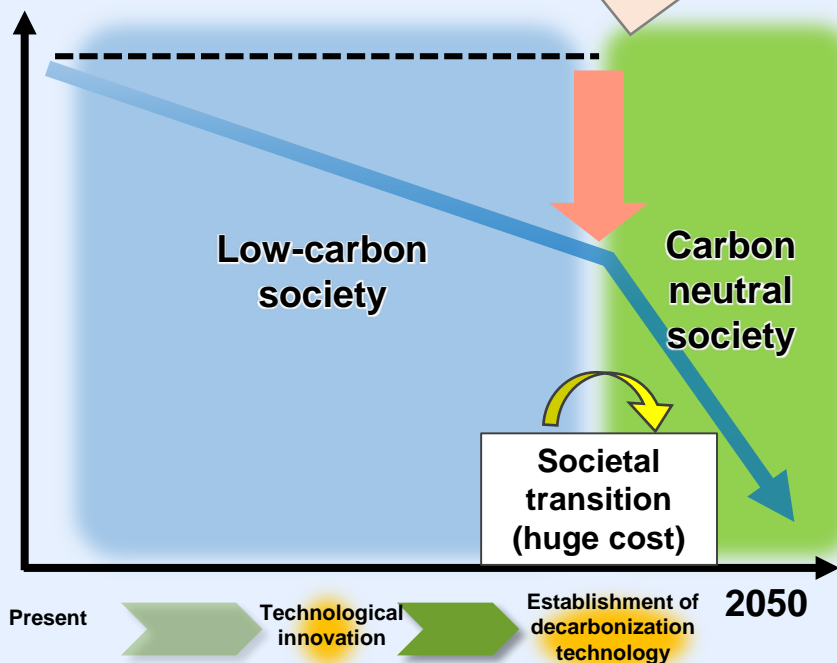
# 08 Effectively reducing CO<sub>2</sub> emissions to achieve carbon neutrality

While decarbonization technology is being developed, it is important to reduce CO<sub>2</sub> emissions in order to minimize the cost required for achieving a carbon-neutral society using the technology, which would otherwise become considerably highly costly.

We strive to continue reducing CO<sub>2</sub> emissions through energy-efficient equipment development and introduction to our customers, fuel conversion from coal to natural gas, and energy management using digital technology.

**It is important to reduce CO<sub>2</sub> emissions as much as possible throughout society in order to reduce the cost required for achieving a carbon neutral society even after putting decarbonization technology into practical use.**

CO<sub>2</sub> emissions throughout society



Effective reduction of CO<sub>2</sub> emissions through enhanced energy conservation and other existing CO<sub>2</sub> emissions reduction measures.

Development of energy-efficient equipment, devices, and services



CHP



Fuel cell



Industrial burner

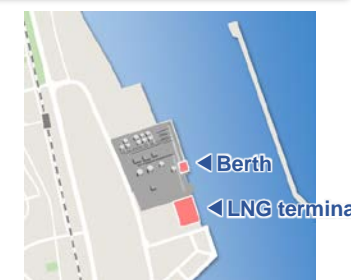


Gas air conditioner



Energy management

CO<sub>2</sub> emissions reduction by converting thermal power generation from coal-fired to LNG-fired



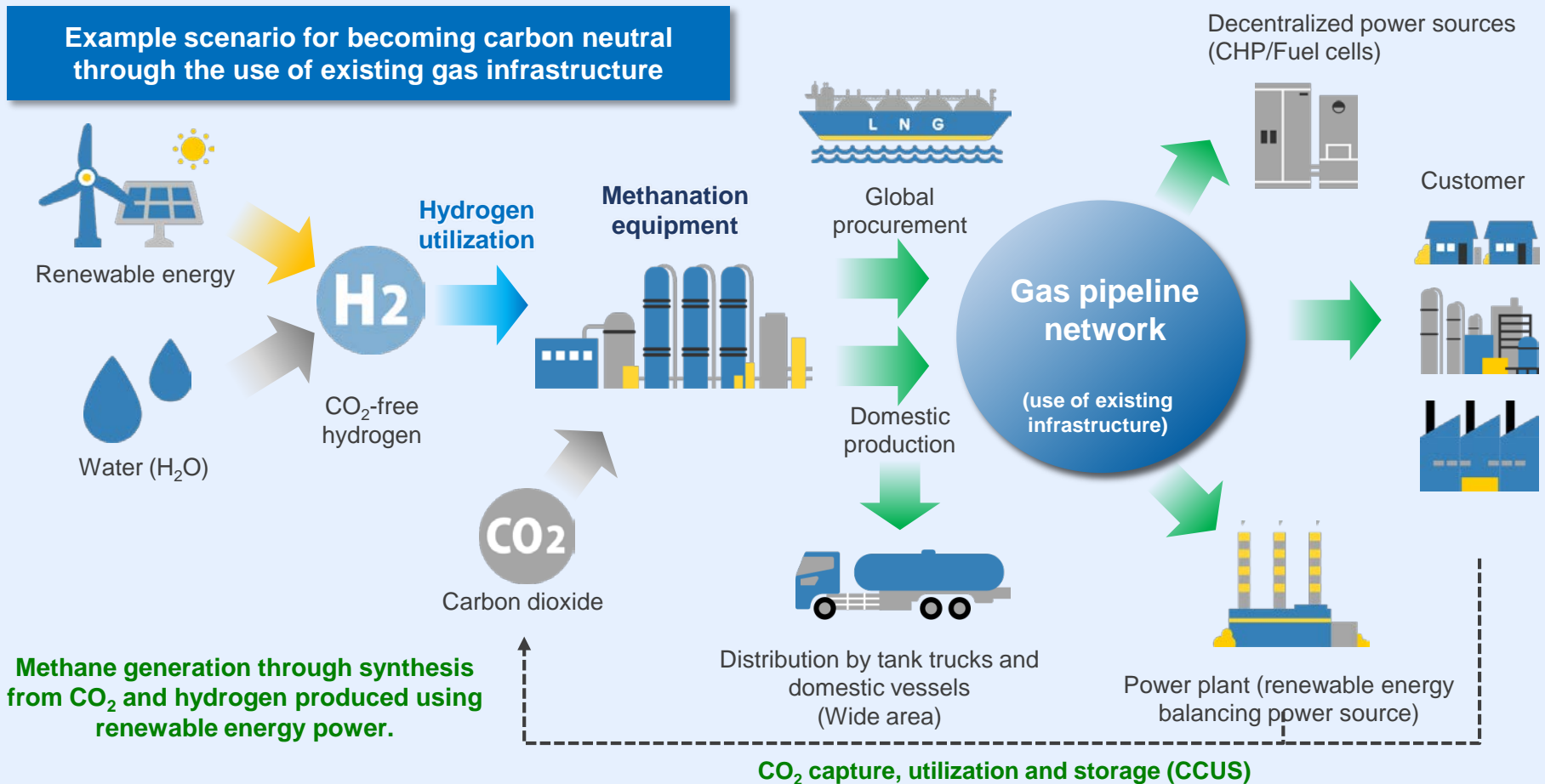
Terminal for accepting coasting LNG vessels, Himuka LNG Co., Ltd. (rendered image)

# Scenario for becoming carbon neutral featuring methanation

Becoming carbon neutral requires the reinforcement of power system while maximizing the use of renewable energy. In the meantime, given the trend of Japan's declining population, it is necessary to use existing infrastructure for reducing social costs. These efforts will also ensure energy resilience as well as carbon neutrality.

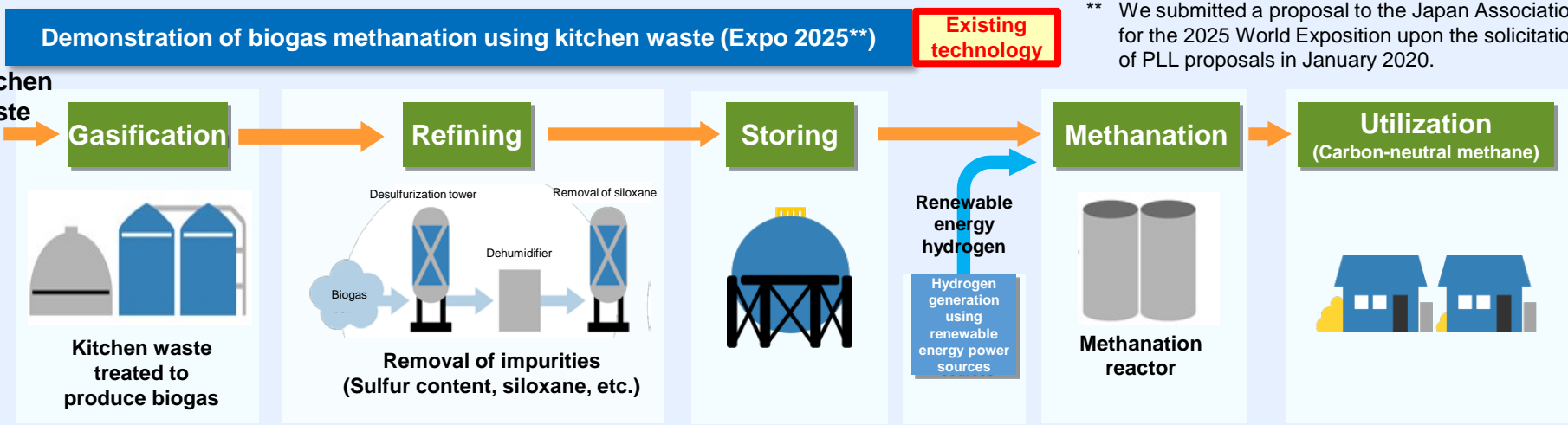
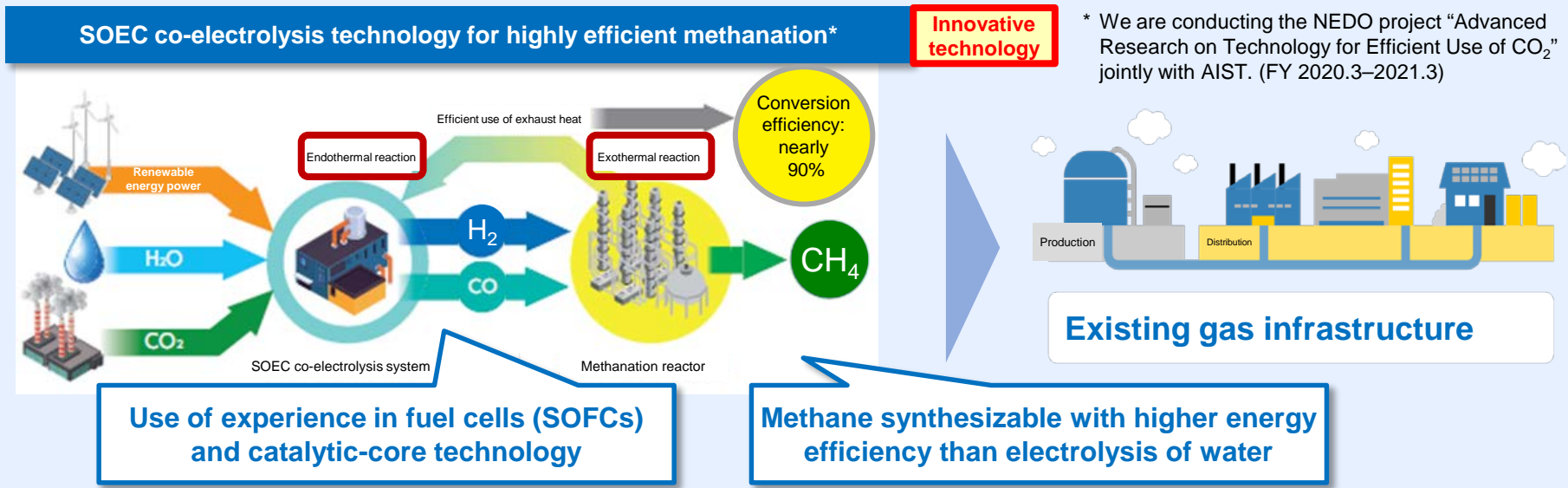
In this scenario, methanation, a technology to generate gas using renewable energy and hydrogen, can play a key role as a solution to the above by efficiently making heat sources carbon-neutral in area energy networks using existing gas supplying facilities.

## Example scenario for becoming carbon neutral through the use of existing gas infrastructure



# 10 Examples of methanation utilization

We pursue R&D on SOEC co-electrolysis, an innovative methanation technology, as well as on other existing methanation technologies that we have been exploring.



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# Approaches to carbon neutrality in our electricity business

As a general energy company, we are developing renewable energy power sources. So far, we have installed approximately 700 MW of such power sources including onshore wind, solar, and biomass in Japan and abroad.

As renewable energy development continues to increase its importance in achieving a carbon-neutral society, we are striving to boost renewable energy power generation capacity by building diverse power sources such as offshore wind and geothermal while expanding our business models.

### Renewable energy-related targets for FY2031.3\*

\* Including FIT power sources

1. 5 GW of renewables development contribution on a global basis
2. Nearly 50% of our power portfolio in Japan consisting of renewables

### Track record of developing renewable energy power sources\*\*

Onshore wind farm  
(8 locations)



Inami Wind Farm

Biomass power plants  
(7 locations)



Matsusaka Woody Biomass Power Plant

Solar power plants  
(7 locations)



Torishima Photovoltaic Power Plant 2



Green Power Fuel Corporation  
Business aimed for stable and sustainable long-term supply of domestic wood for biomass power

Approx. 700 MW



5 GW  
Including Japan  
& overseas

Power sources  
developed/  
owned

Electricity  
procured

### Diversification of power sources



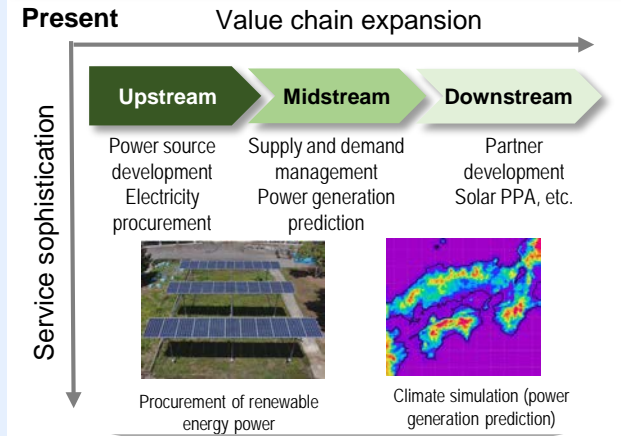
Rendered image

Offshore wind power  
(Under business feasibility study in Saga Prefecture and elsewhere)



Geothermal  
(Under business feasibility study in Hokkaido Prefecture and elsewhere)

### Business model expansion



Versatile responses to RE100 and other needs

\*\* Domestic and already (or being) developed

As of end December 2020

By FY2031.3

# Carbon Neutral Research Hub

We have been developing our basic carbon-neutral technology as well as other technologies including gas synthesis, advanced use of natural gas, and materials development, in our labs located in the Torishima area on Osaka Bay, where we once produced coal gas and oil gas, which we designate as the Carbon Neutral Research Hub for our Group.

As this Research Hub in Torishima, we pursue new R&D programs such as on the production and use of carbon neutral fuels and on storage batteries through technological collaborations within the Daigas Group and joint research projects with our partners.

## OSAKA GAS Promoting future-oriented carbon-neutral R&D



Energy Technology Laboratories



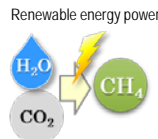
Clean combustion technology (hydrogen, ammonia, etc.)



Novel hydrogen generation technology



Methanation catalyst



Innovative methanation

Renewable energy power

## OSAKA GAS MARKETING Daigas G&P Solution Daigas Energy Contributing to achieving carbon neutrality through our business



CHP/burner



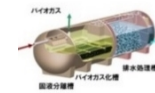
Fuel cell



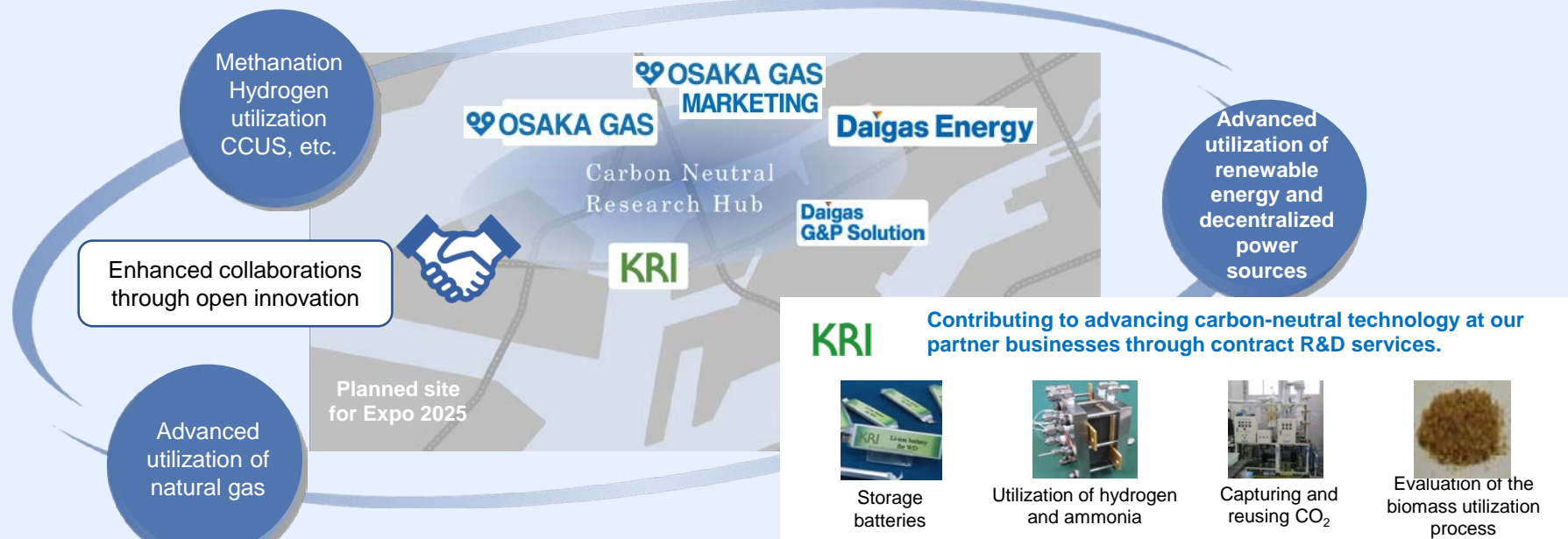
VPP/Storage batteries



Hydrogen generator



Biogas production



Methanation  
Hydrogen  
utilization  
CCUS, etc.

Enhanced collaborations  
through open innovation

Advanced  
utilization of  
natural gas

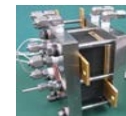
Planned site  
for Expo 2025

Advanced  
utilization of  
renewable  
energy and  
decentralized  
power  
sources

**KRI** Contributing to advancing carbon-neutral technology at our partner businesses through contract R&D services.



Storage batteries



Utilization of hydrogen and ammonia



Capturing and reusing CO<sub>2</sub>



Evaluation of the biomass utilization process

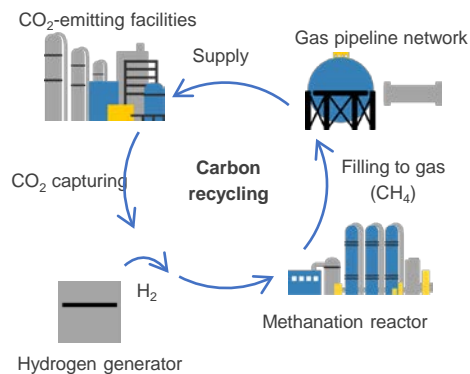
## 13

## Close collaborations with various partners for carbon neutrality

We plan to work in industry-wide and cross-industry alliances and collaboration with the government offices for projects that requires support from relevant parties. Examples of those projects include large-scale carbon recycling, overseas supply chain development, and hydrogen utilization.

## Promoting carbon recycling

- Exploring carbon recycling with energy business operators and our customers in an extensive range of industries including steel and chemical.
- Studying specific measures for the efficient capturing of CO<sub>2</sub>, in collaboration with industrial players.



## Building an overseas supply chain

- Building a supply chain with the aim of generating carbon-neutral methane abroad for import to Japan.
- Creating alliances with plant manufacturers and trading companies. Collaborate with the government regarding system creation and other matters for imports from overseas.



(Left) Courtesy of Freeport LNG Development  
(Right) LNG MARS of which we are a joint owner

## Utilization of hydrogen and other resources

- Promoting the utilization of carbon-neutral fuels such as hydrogen and ammonia at local networks, power plants, and our customers while proceeding with the novel hydrogen generation technology development project on which we are currently working.
- Acquiring technology development information and expanding partnership through consortiums.



CCR研究会

The logo for Daigas Group features the word "Daigas" in a bold, blue, sans-serif font. A small, downward-pointing triangle is positioned above the letter 'i', with a yellow-to-orange gradient. Below "Daigas", the word "Group" is written in a smaller, blue, sans-serif font.

**Daigas**  
Group

## Chemical looping combustion technology

Chemical looping combustion is a novel combustion technology, which can simultaneously produce hydrogen, power, and  $\text{CO}_2$  from hydrocarbon fuels. As a party selected in November 2020 in a NEDO's project to develop this technology, we have commenced R&D activities jointly with JCOAL.

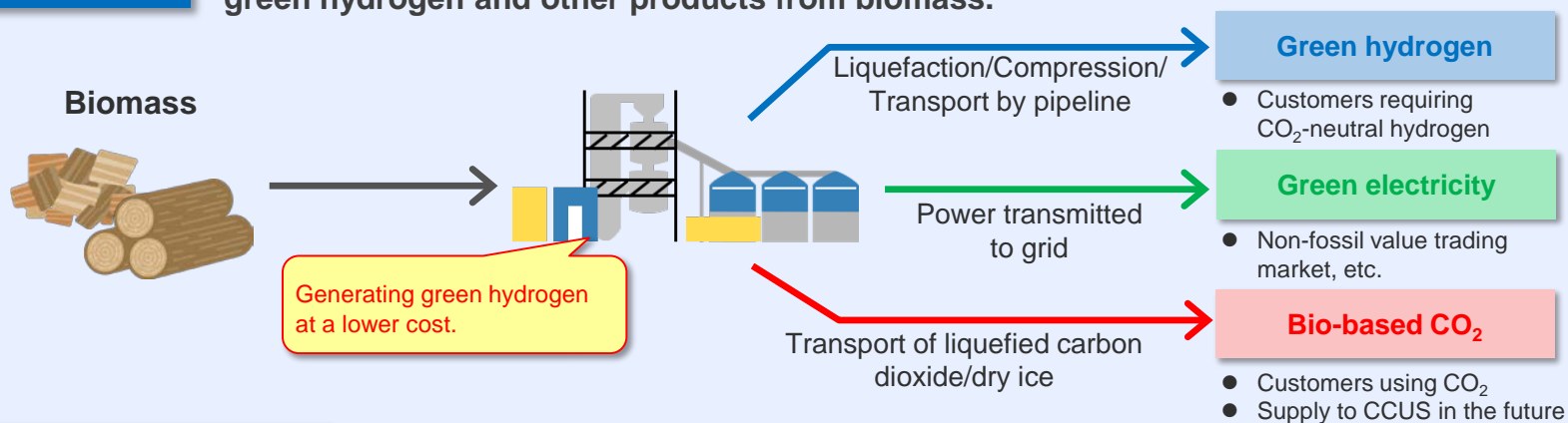
We intend to develop underlying technology and conduct a process verification experiment using 300 kW-scale test equipment until the end of FY2025.3 (planned).

Based on the results of this project, we will produce and supply green hydrogen and other products from biomass to help our customers achieve carbon neutrality.

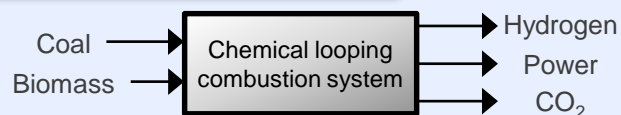
\* New Energy and Industrial Technology Development Organization \*\* Japan Coal Energy Center

### What we aim to be

Contributing to achieving carbon neutrality at customers' premises by producing and supplying green hydrogen and other products from biomass.

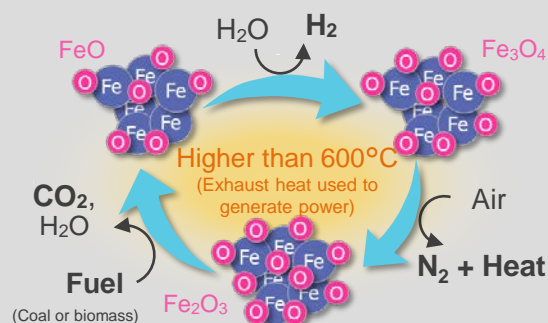


### NEDO project activities



- Development of a technology designed to generate hydrogen and power from coal or biomass while capturing  $\text{CO}_2$ ; Captured  $\text{CO}_2$  is projected to be stored or utilized.
- We are developing underlying technology and conducting a demonstration experiment of 300 kW-size equipment during the period from November 2020 to the end of FY2025.3.
- It is a joint project with JCOAL. While JCOAL aims to commercialize chemical looping combustion as a technology for the clean use of coal, we aim to commercialize the technology for biomass utilization.

### <Chemical looping combustion technology>



- It is a technology for burning fuel using a metal oxide (e.g. iron oxide) as an oxygen carrier
- It produces high-purity  $\text{CO}_2$  without additional  $\text{CO}_2$  capturing equipment
- It generates hydrogen from water reacting with metal oxides