Daigas Group
Energy Transition 2030

March 2023

Osaka Gas Co., Ltd.

Background of formulating Energy Transition 2030

The Daigas Group announced **the Carbon Neutral Vision** in January 2021, **aiming for net zero by 2050.** To achieve the target, we are working on effective initiatives.

Japan's transition to a low-carbon society has gained momentum with the government's announcement in April 2021 of a 46% reduction in greenhouse gas emissions by 2030. Meanwhile, **energy security has become an urgent issue** for the country due to changing global economy and increasing energy market volatility.

Under these circumstances, the Daigas Group **strives to ensure the stability and security of the energy supply and achieve the carbon neutrality** of energy for a sustainable future.

Daigas Group
Carbon Neutral Vision

Purpose of Energy Transition 2030

We have formulated **Energy Transition 2030** to share with stakeholders the Daigas Group's strategy for achieving carbon neutrality by 2050, including:

1. **Overall picture of our transition to low carbon and carbon neutral energy**
2. **Our transition initiatives and solutions for a lower carbon society in 2030.**

We continue working with stakeholders **to create value for a sustainable future by taking on the challenge of resolving issues in the energy field.**

Daigas Group

Carbon Neutral Vision to become carbon neutral

Daigas Group's approaches to decarbonization

2050

Energy Transition 2030 2030

1. **Overall picture of Daigas Group's energy transition**
2. **Daigas Group's initiatives and solutions for a lower carbon society in 2030**

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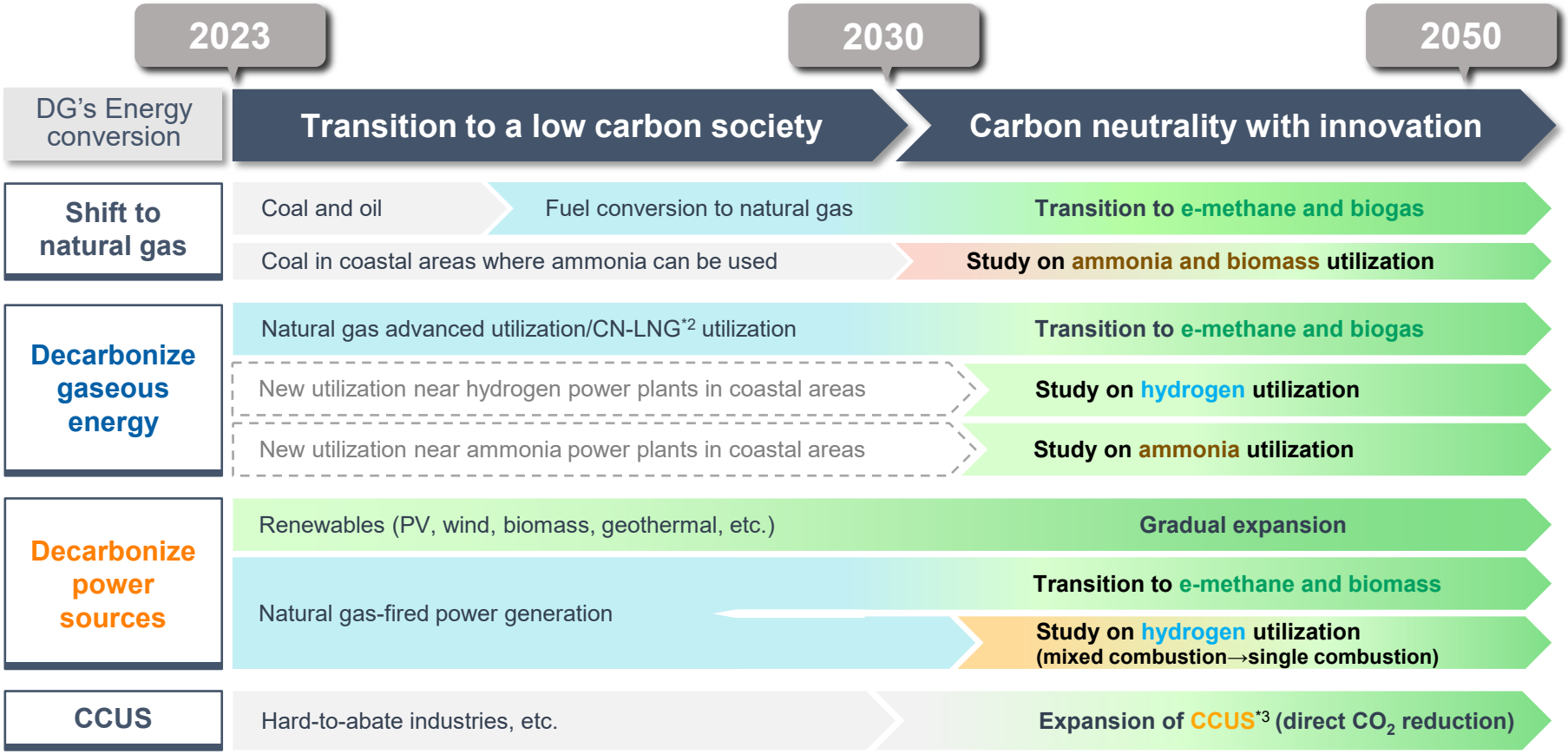
Note: The target years 2030 and 2050 mean the fiscal years ending in March 2031 and March 2051 respectively.

1. Overall picture of Daigas Group's energy transition

Energy Transition 2030

Daigas Group's energy transition

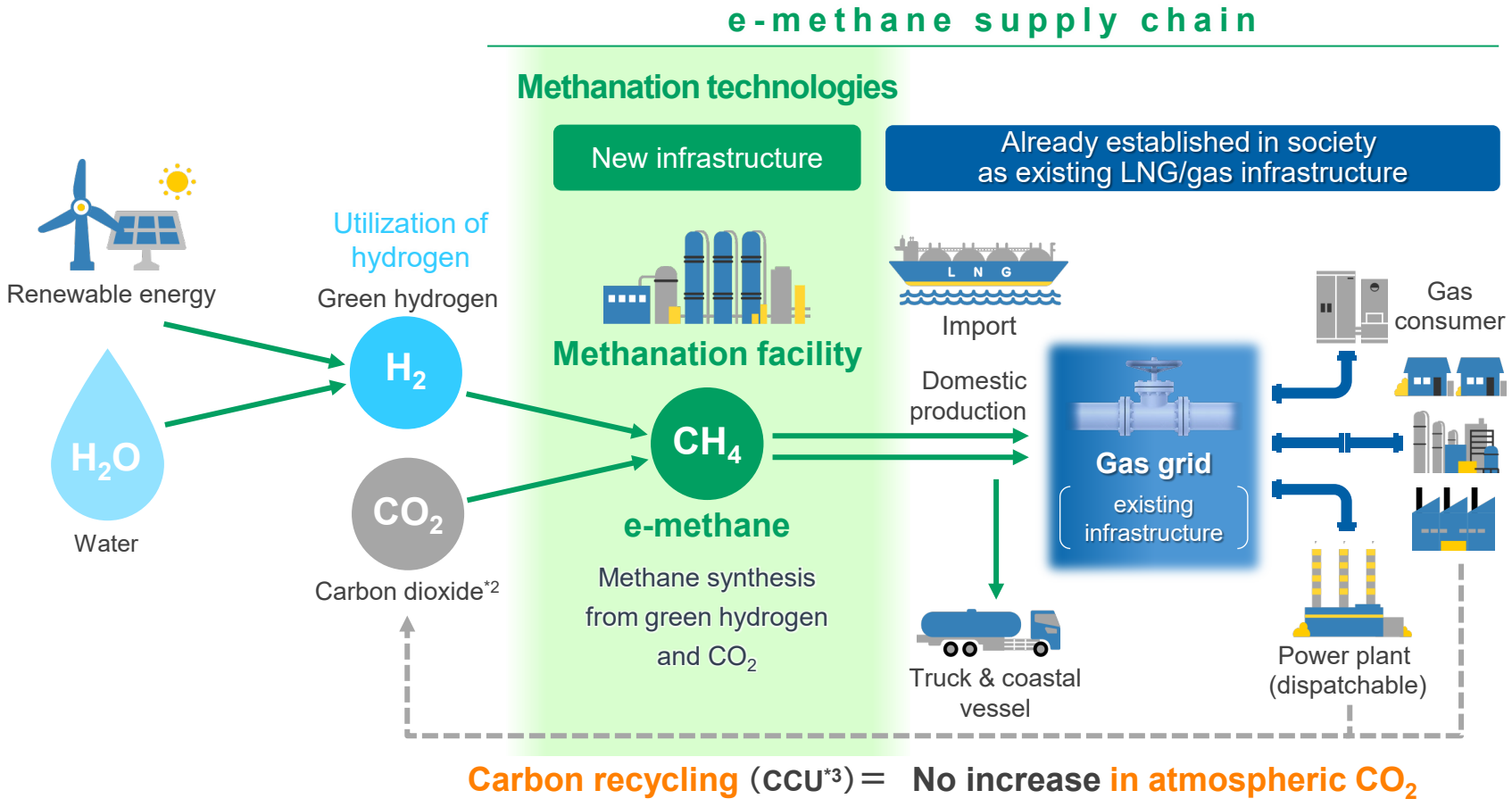
- Providing **optimal energy carriers through suitable supply methods**, following **S+3E**[*1] and in accordance with customers' **energy usage attributes**
- Working on **phased transition** to minimize the social costs for energy conversion, **especially in the thermal energy field**



*1 The Japanese government's basic energy policy, Safety + Energy security, Economic efficiency, and Environment
*2 Carbon Neutral-LNG, which is considered to produce no CO2 on a global basis when greenhouse gases emitted in the supply chain from natural gas production to combustion are offset by CO2 absorbed and reduced in a separate process from the value chain
*3 Carbon dioxide Capture, Utilization and Storage

e-methane: key carbon neutral energy carrier

- **e-methane** is a **carbon neutral hydrogen carrier**[*1] synthesized through methanation **using CO_2 captured from emissions**
- Working on **phased transition** to minimize the social costs for energy conversion, **especially in the thermal energy field**



*1 Hydrogen compounds that achieve efficient storage, transport, and utilization of hydrogen, which cannot be stored and transported over long distances efficiently in its gaseous state

*2 Biogenic CO_2 and possibly DAC (Direct Air Capture) might be utilized in the future.

*3 Carbon dioxide Capture and Utilization

Hydrogen carrier utilization according to attributes

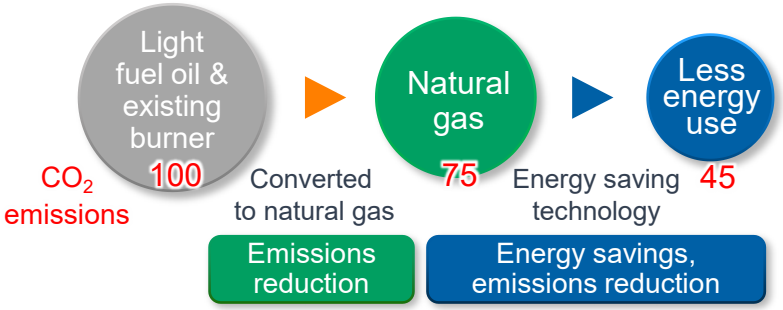
- Utilization of hydrogen carriers **according to each carrier's energy attributes**
- Energy conversion **during transition** according to **carrier's supply stability** and attributes

	H_2 Hydrogen (LH2)	NH_3 Ammonia	CH_4 e-methane
Energy properties	• Liquefaction temp.: −253 ℃ ◎ Toxicity: No • Combustion rate: Fast (8 times faster than natural gas) • Combustion calorific value: 12.8 MJ/m^3 • Minimum ignition energy: 0.01 mJ	◎ Liquefaction temp.: −33 ℃ • Toxicity: Yes • Combustion rate: Slow (1/5 of natural gas) • Combustion calorific value: 17.1MJ/m^3 • Minimum ignition energy: 14 mJ	• Liquefaction temp.: −162 ℃ ◎ Toxicity: No • Combustion rate: Same as natural gas ◎ Combustion calorific value: 39.9 MJ/m^3 • Minimum ignition energy: 0.3 mJ
Points to consider	◎ No emissions from combustion • No compatibility with existing gas infrastructure/equipment ⇒ Heat per gas volume: 1/3 of methane • High energy required for liquefaction, transport, and storage	◎ No CO_2 emission from combustion • Proven track record in industrial application • No compatibility with existing gas infrastructure/equipment • Safety issue due to toxicity in case of leakage	◎ Compatibility with existing gas pipelines/equipment → easier to convert fuels from natural gas, lower social costs • Composition mostly the same as natural gas • CO_2 accounting rule needed for CCU
Usage	◎ Fuel to replace natural gas for thermal power generation • General use near coastal areas (new hydrogen pipeline is needed for inland supply)	◎ Fuel to replace coal for thermal power generation • Industrial use near coastal areas (new ammonia pipelines are needed for inland supply)	◎ Fuel for existing gas users ◎ Utilization in urban and coastal areas • Fuel for existing gas-fired power plants • Fuel for ships

CO_2 emissions reduction with natural gas utilization

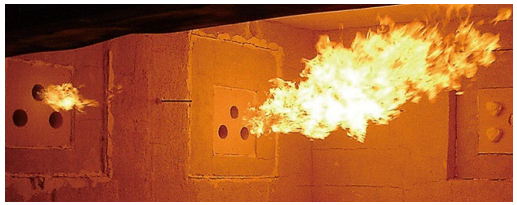
- Reducing emissions with **energy-saving technologies (e.g., CHP)** besides **fuel conversion**
- **Saving energy and enhancing energy resilience** with **CHP** utilizing waste heat
- Seamless transition by using **natural gas/e-methane** in existing equipment as is

Fuel conversion to natural gas
(emissions reduction in the thermal energy field)



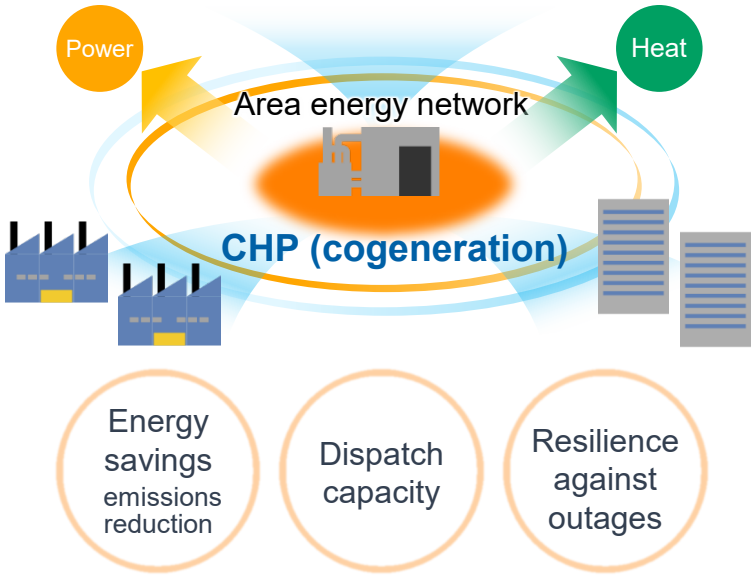
Energy conservation technology

Industry furnace



High efficiency burner

Advanced utilization of natural gas
(introduction of CHP)



Seamless transition from natural gas to e-methane

e-methane use in natural gas infrastructure/equipment
fit for fuel conversion & natural gas advanced utilization

Seamless transition to **net zero emissions**
with no burden on customers

Contribution to society-wide emissions reduction

- Contributing to society-wide emissions reduction by supplying natural gas, **converting fuels** from coal/oil to **natural gas**, and **introducing CHP units and high-efficiency gas appliances**

Fuel conversion to natural gas from other fuels

- Converting from oil/coal to natural gas/LNG to significantly reduce emissions
- Converting fuels to natural gas where gas infrastructure has not yet been developed in Japan and Asia

Daio Paper Corp. Mishima Plant

Converting from oil (lime kiln)

−22,000 t/year

Asahi Kasei Corp. Nobeoka area

Converting from coal (thermal power plant)

−160,000 t/year

Toyobo Co., Ltd. Iwakuni Office

Converting from coal (thermal power plant)

−80,000 t/year

Promoting wider use of CHP units

- Saving energy through waste heat utilization and supplying power in power outages as a BCP[*1] measure
- Cumulative installed capacity: ~1.5 GW (equivalent to ~5% of the electricity demand in the Kansai area)

Promoting wider use of high efficiency gas appliances

- ENEFARM: ~170,000[*2] units (~310,000 tons of annual emissions reduction)
- Eco-Jozu: ~1.07 million units (~260,000 tons of annual emissions reduction)

ENE·FARM エネファーム

ecoジョーズ®

*1 Business Continuity Planning *2 Cumulative units sold as of October 2022 *3 Cumulative units sold as of March 2022

Enhancement of avoided emissions recognition

- **Aiming to enhance the recognition of avoided emissions** as an indicator of the contribution to **society-wide CO_2 emissions reduction**
- **GHG Protocol**[*1]-based calculation **does not cover avoided emissions**

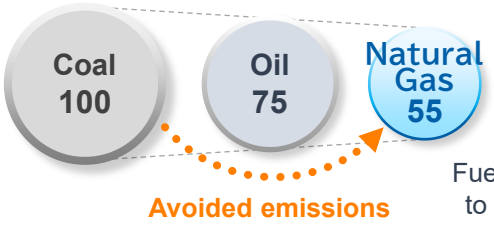
What are avoided emissions?

Quantified emissions reduction through products and services of one company provided to others

Calculation based on the guidelines of METI, the Ministry of Economy, Trade and Industry

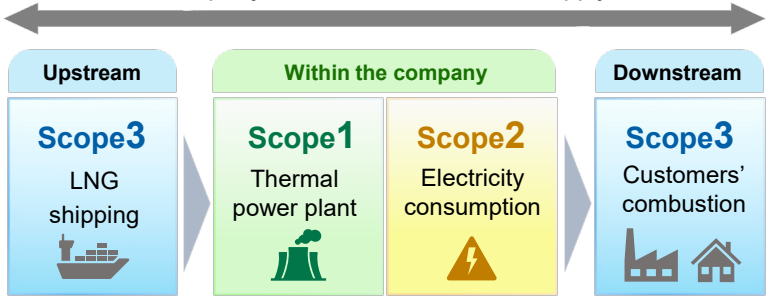
Indicator of society-wide CO_2 emissions reduction through contribution to other companies' emissions reduction

CO_2 emissions per same calorific value[*2]



GHG Protocol-based emissions calculation

Each company's emissions from entire supply chain



[Issue] How to evaluate avoided emissions

< Avoided emissions calculation example >

Customer's emissions

Reduced by switching from coal to **natural gas**

+

Osaka Gas' emissions

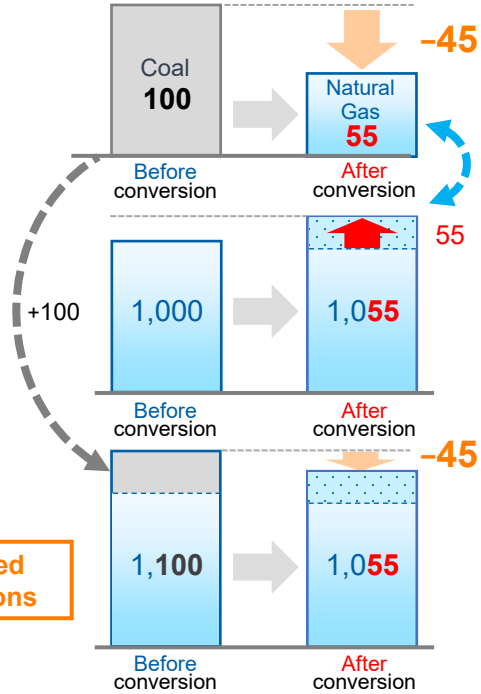
Scope3 increased due to gas sales growth

Society-wide emissions

Scope3 increases while **society-wide emissions decrease**

After conversion: 1,055 − Before conversion: 1,100 = **−45**

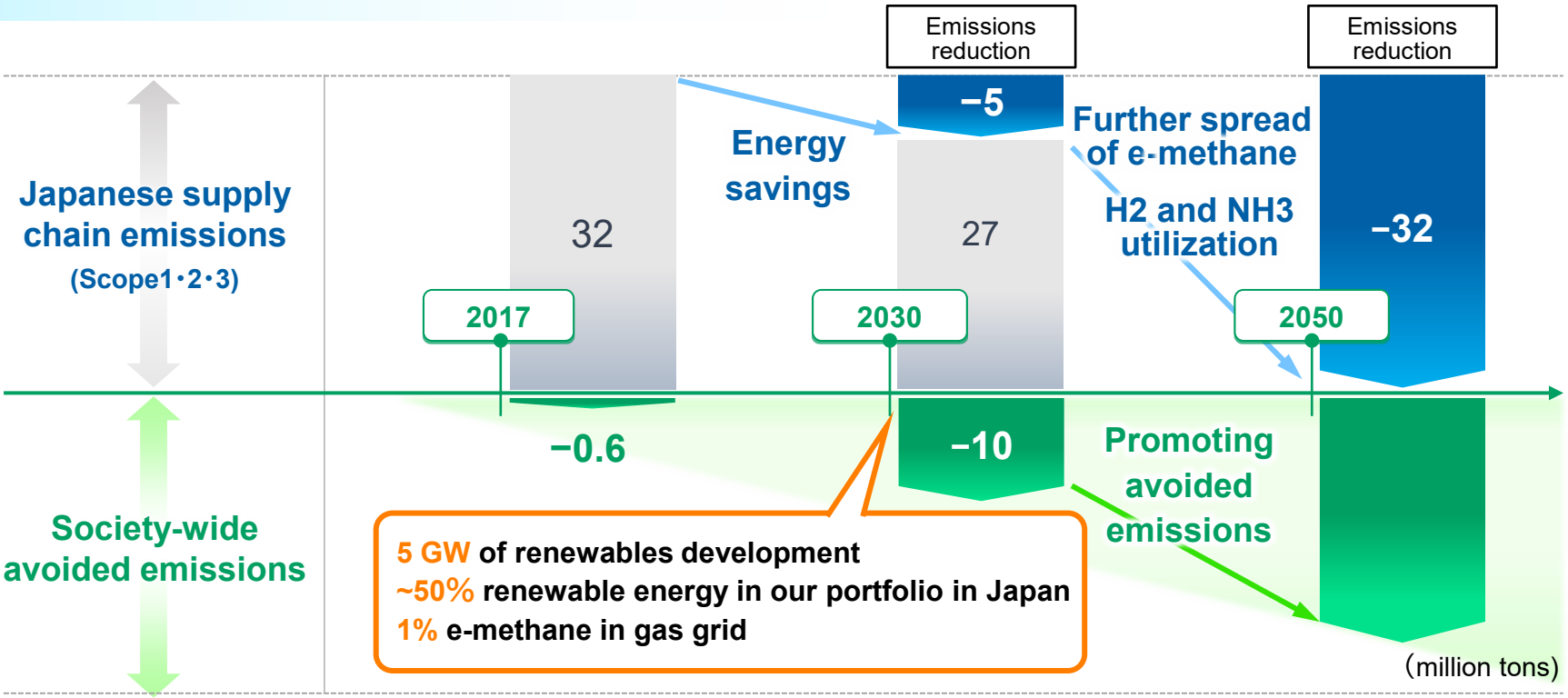
Avoided emissions



*1 International standard for calculating and reporting GHG missions
*2 Prepared based on the Ordinance Concerning Calculation of GHG Emissions from Business Activities of Specified Emitters issued by METI and the Ministry of the Environment

Daigas Group's CO_2 emissions reduction roadmap

- 2030 targets: **5 mil. tons of CO_2 emissions reduction** in Japan through 1% e-methane injection into the gas grid, etc., and **10 mil. tons** of society-wide **avoided emissions** through business activities



Decarbonize power	Low-carbon/carbon neutral power (renewables, e-methane, hydrogen, and CCUS)
Decarbonize gas	Emissions reduction with natural gas → Carbon neutrality with e-methane
Reduce in-house emissions	Net zero in our office buildings and vehicles
Investment valuation	Application of internal carbon pricing

2. Daigas Group's initiatives and solutions for a lower carbon society in 2030

2030 target of 1% e-methane in gas grid

- e-methane: selected as **next-generation thermal energy industry*** with four value propositions
- **2030 target: 1% e-methane** in the gas grid to expand e-methane's practical application

* One of 14 priority fields of the Green Growth Strategy*1

Value propositions of e-methane

Value proposition 1
Decarbonized heat demand
Decarbonizing heat demand, which accounts for **60% of energy,** including high-temperature heat **that cannot be generated by electricity**

Value proposition 2
Lower social costs
Significantly reducing social costs by **using the existing gas infrastructure and equipment without modification**

Value proposition 3
Enhanced energy security
Mitigating geopolitical risks through diversified sources of e-methane produced in various locations in Japan and overseas

Value proposition 4
Carbon neutral Asia
Exporting competitive Japanese industries and contributing to **the environment conservation and economic growth in Asia and Japan**

Daigas Group

2030 target
1%
e-methane
in the gas grid
(~60 million m^3/year*2)

Next-generation thermal energy industry

One of the Green Growth Strategy's 14 priority fields
Selected Projects eligible for the Green Innovation Fund support

*1 A compilation of policies and action plans for the industrial sectors with growth potential in order to create a virtuous circle between the economy and the environment to achieve carbon neutrality by 2050,

*2 Based on gas sales volume in FY2020

e-methane supply chain development in Japan

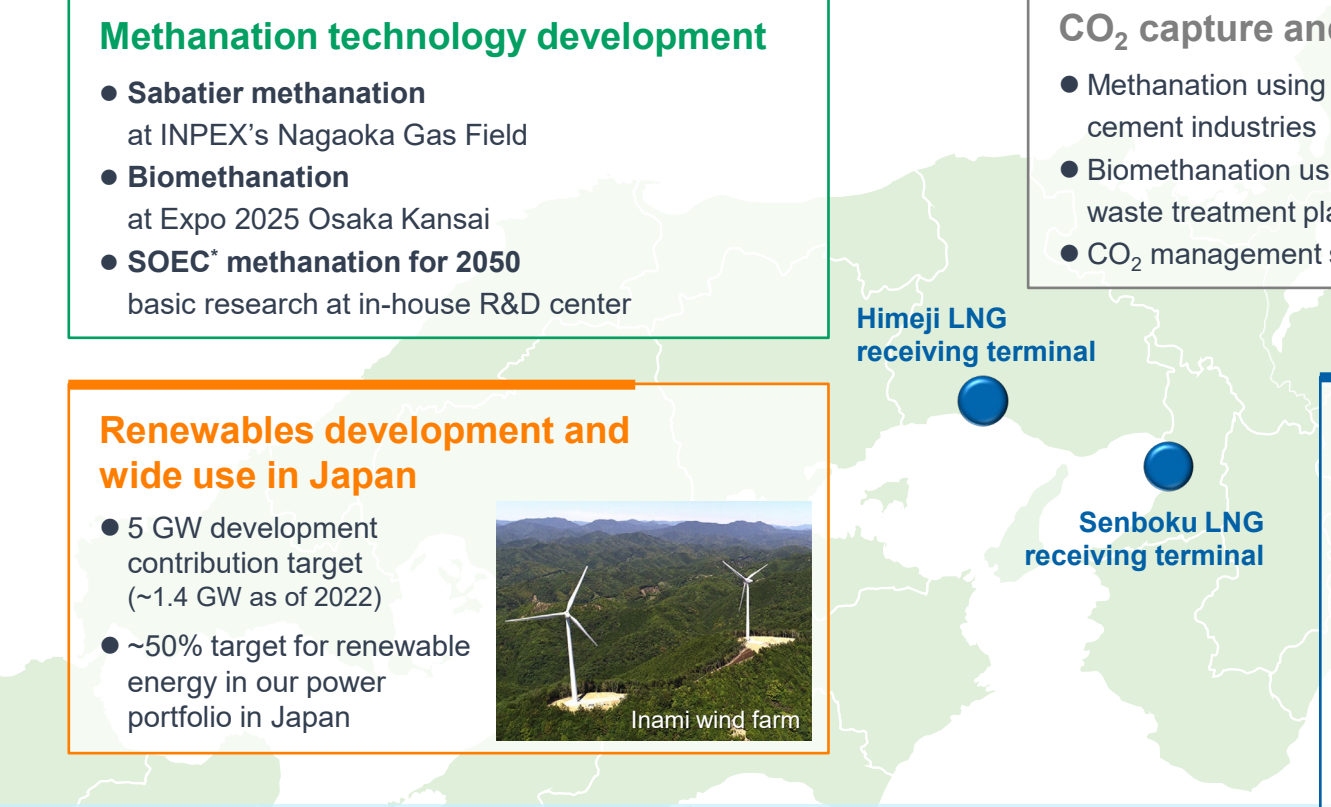
- Pursing **methanation technology development**, **site analysis for e-methane production, and procurement of renewable energy, hydrogen, and CO_2** to achieve e-methane introduction in 2030
- **Development of wind, solar, and other renewables**, utilization of hydrogen as fuel for gas-fired power plants, and **verification of methanation technologies with CO_2 capture and utilization**

Methanation technology development

- **Sabatier methanation**
  at INPEX's Nagaoka Gas Field
- **Biomethanation**
  at Expo 2025 Osaka Kansai
- **SOEC* methanation for 2050**
  basic research at in-house R&D center

CO_2 capture and utilization testing

- Methanation using captured CO_2 with steel, chemical, cement industries
- Biomethanation using biogas and CO_2 from sewage and waste treatment plants
- CO_2 management system with carbon recycling



Renewables development and wide use in Japan

- 5 GW development contribution target (~1.4 GW as of 2022)
- ~50% target for renewable energy in our power portfolio in Japan

Hydrogen utilization study

- H_2-mixed fired power plants
  → procurement from overseas, storage tanks, vaporizers, etc.

Study on e-methane for gas market in Kansai

Verifying underlying technologies, developing supply chain, and establishing a domestic implementation model

* Solid Oxide Electrolysis Cell

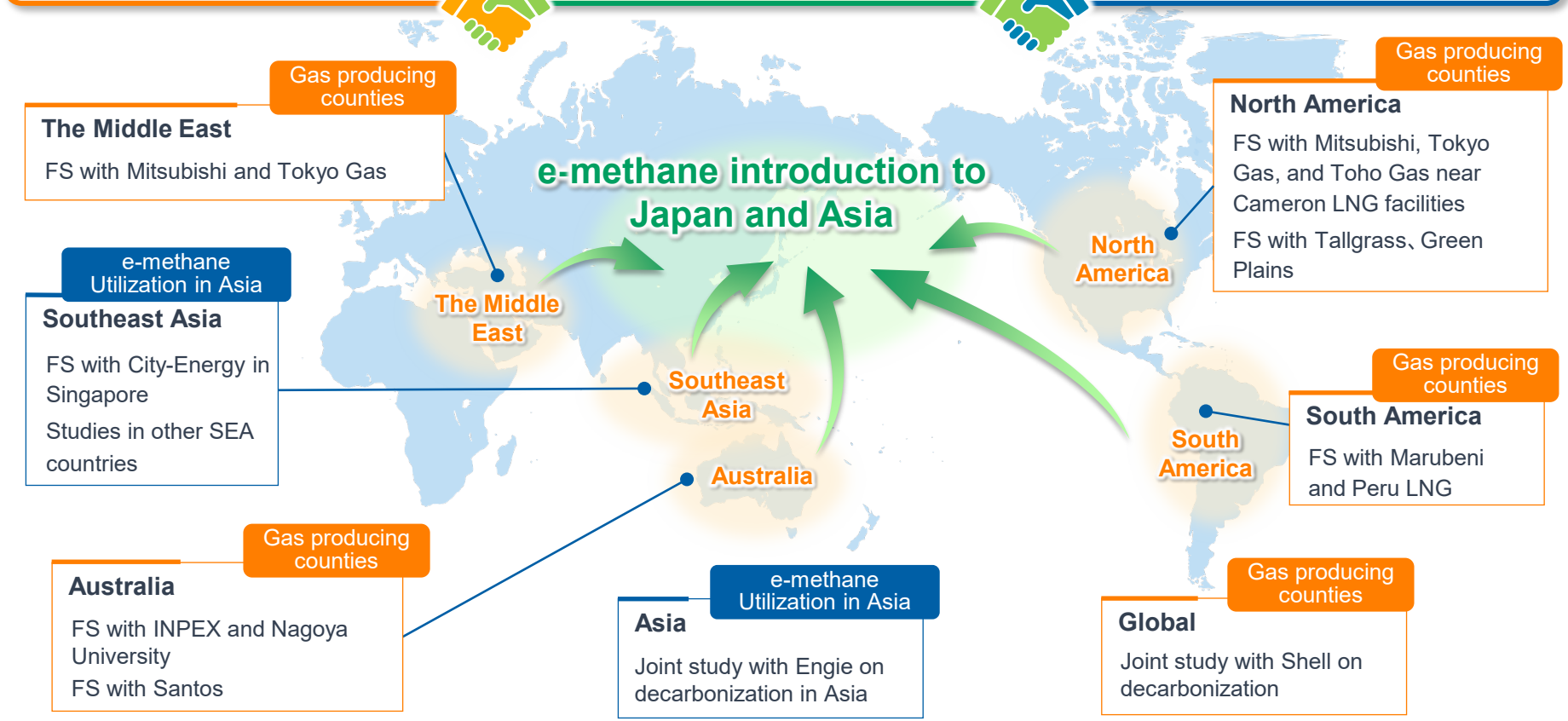
e-methane supply chain development overseas

- Conducting **feasibility studies and basic designs** with domestic and overseas operators to **establish supply chains in Japan and overseas** for e-methane practical application in Japan starting in 2030
- Identifying suitable e-methane production location among sites around the world, where existing LNG facilities are available, for **stable procurement** and **wide use of e-methane in Japan and Asia**

New energy industry for gas producing countries

Japan's decarbonization and energy security

Asia's decarbonization through e-methane utilization



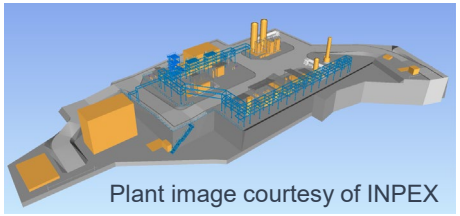
Methanation technologies for producing e-methane

- Scaling up **Sabatier methanation**, a conventional technology, and commercializing **biomethanation**, an innovative technology for producing energy for local use, to introduce e-methane by 2030
- Establishing **SOEC methanation**, a highly efficient next-generation technology, for 2050

① Sabatier methanation

- Early large-scale commercialization
- Joint NEDO project*1 with INPEX
- World's largest scale 400m³/h (10,000 households), in-house proprietary catalyst technology

Demonstration near INPEX's Nagaoka Gas Field



Plant image courtesy of INPEX

② Biomethanation

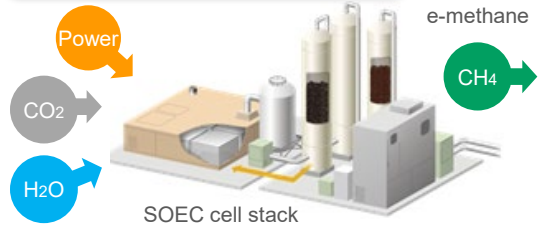
- Generating energy for local use
- At Expo 2025*2 & sewage plants*3
- Methane synthesis by methanogen, advanced use of biogas derived from garbage and sewage sludge

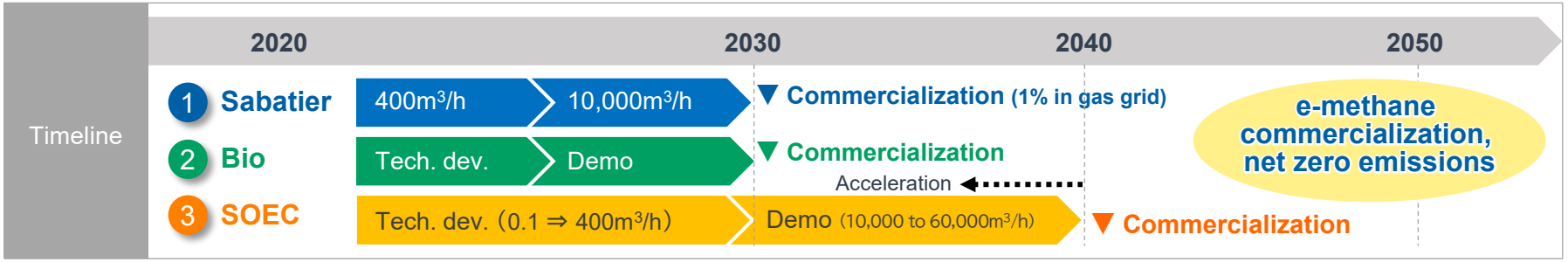
Demonstration at Expo 2025

③ SOEC methanation

- Enhancing efficiency for lower cost
- Green Innovation Fund Project*4
- Combining SOEC co-electrolysis with methanation, direct methane synthesis from water and CO_2

Methanation technology for 2050





*1 Development of CO_2 Utilization Technology for Gaseous Fuels, *2 Ministry of the Environment-funded FY2022 Demonstration Project,
*3 Ministry of Land, Infrastructure, Transport and Tourism's FY2022 Sewerage Application Research,
*4 SOEC Methanation Technology Innovation Project under the Innovative Technology Development for Synthetic Methane Production

Carbon neutral initiatives in power business

- Aiming for **5GW** of renewable energy development contribution by developing various types of renewables with partners across Japan while **decarbonizing thermal power sources**

Renewable energy-related targets for 2030*1

1. **5GW of renewables development contribution on a global basis**
2. **~50% renewable energy in our power portfolio in Japan**

Renewable capacity as of March 2022

On-shore wind (10 sites)

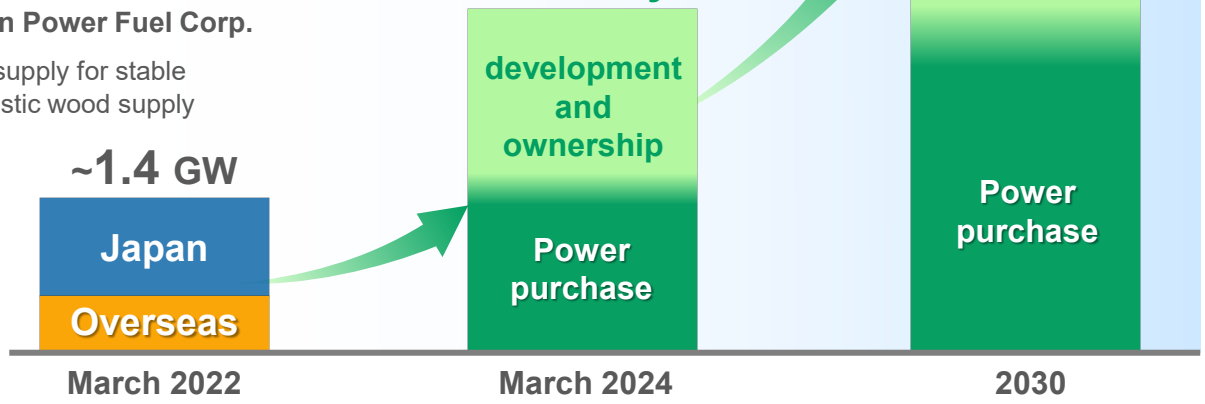
Biomass (8 sites)

Green Power Fuel Corp.
Fuel supply for stable domestic wood supply

Solar PV (>100 sites)*2

Decarbonization

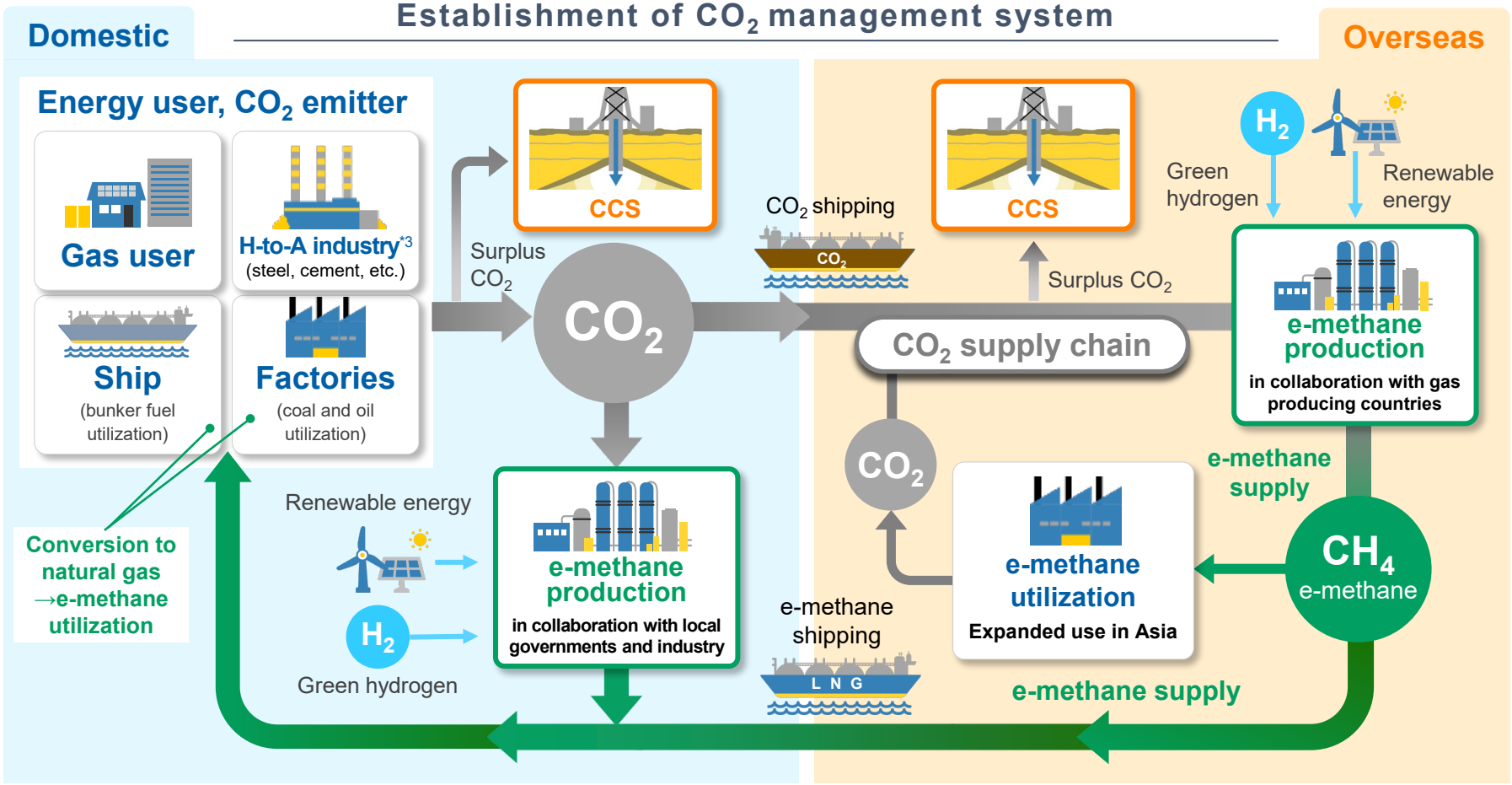
e-methane, hydrogen, CCUS, battery, VPP*3



*1 Including FIT power sources
*2 Under development in Japan
*3 Virtual Power Plant

CO_2 value chain development

- **Producing and supplying e-methane**, which doesn't require **new infrastructure development** and gas equipment replacement, **reusing emitted CO_2** (CCU*1)
- Establishing CO_2 supply chains and injecting and storing surplus **CO_2 deep underground using CCS***2
- Developing a **CO_2 management system** to monitor and control CO_2 generated in above processes



*1 Carbon dioxide Capture and Utilization

*2 Carbon dioxide Capture and Storage

*3 Hard-to-abate industry

New decarbonization technology development

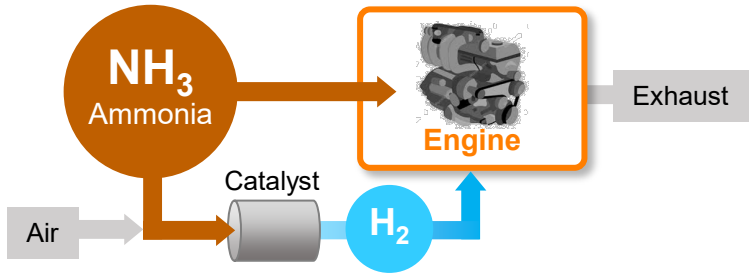
- **New technologies that contributes to emissions reduction**, based on our proprietary technologies
- Accelerating R&D, communicating information, and promoting alliances at **new R&D center**

Hydrogen and ammonia combustion

Technologies for stable combustion

Natural gas | 100% hydrogen | 30% ammonia

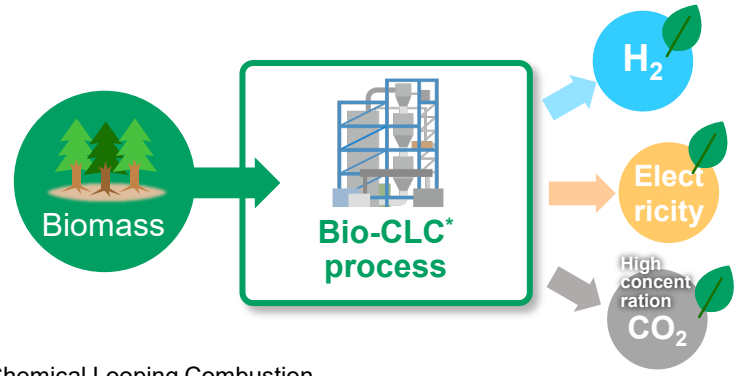
Development of burner nozzles



Development of a small engine system using ammonia as a single fuel
(collaboration with Toyota Industries Corp.)

Carbon neutral hydrogen production (chemical looping combustion)

Technology for producing hydrogen, power, and high concentration CO_2 simultaneously by reacting biomass fuel, water, and air through iron oxide circulation



* Chemical Looping Combustion

Radiative cooling materials

SPACECOOL

Developing materials that reduce indoor temperature lower than outside without using energy

New R&D center

Full operation scheduled for 2025 to accelerate R&D, communicate information, and promote alliance

Daigas Group's solutions: residential sector

- Offering energy solutions for customers' **comfortable living** in addition to **3E**, **Environment**, **Energy security**, and **Economic efficiency**

Environment

[1] High-efficiency water heaters

- **Ene-Farm: Fuel cell unit**
  High-end energy-saving model, ICEF*1 2020 world's best innovation

- **Eco-Jozu: Water heater**
  Fit for limited installation space

[2] Promotion of renewable power

- **Solar PV:** Home carbon-free power generation
- **Renewable power supply:** Style Plan E-ZERO

[3] No wasted power generated at home

- **Utilization of storage batteries:**
  Eliminating a waste of power generated at home, combined with Ene-Farm and solar PV

3電池 SMART ENERGY HOME

Combination of fuel cells, batteries, and solar PV for reduction of 90% power purchase and 80% emissions

Energy security (resilience)

- ENE FARM **stand-alone in outage**
- 3-battery system to supply power from solar PV, battery, Ene-Farm
- Demand response for stable power supply in power shortage

Supplying power and hot water in outage

Economic efficiency

- Solar PV: **Reducing** power purchase and **selling surplus power**
- **Sumai-Roof, Sumai-Roof Plus**: free-of-charge solar PV installation services

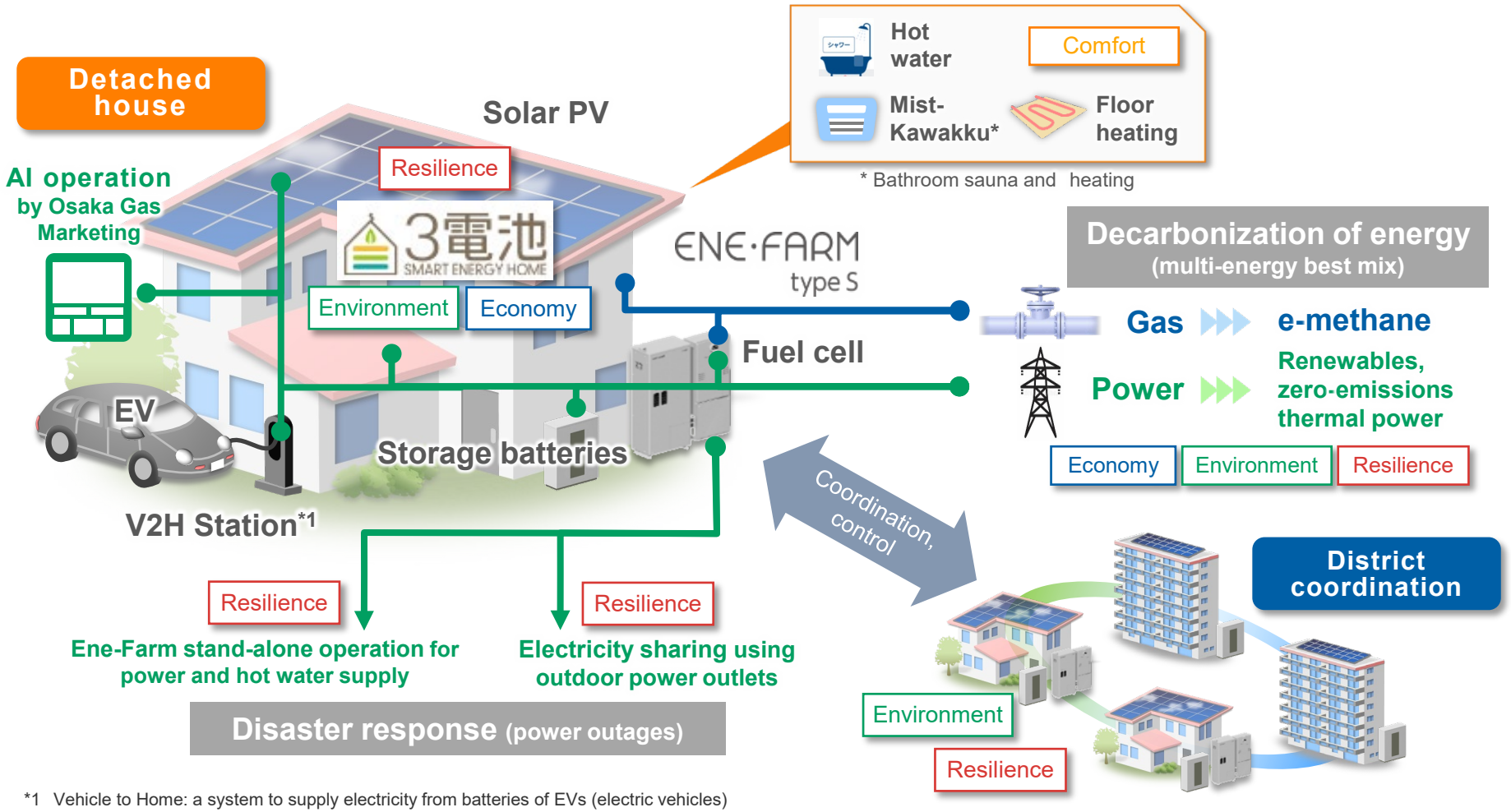
Comfortable living

- Stable hot water supply with Ene-Farm, Eco-Jozu, and other water heaters
- Gas-fired hot-water floor heating

*1 Innovation for Cool Earth Forum: International conference organized by METI and NEDO on resolving climate change with innovation

Daigas Group's solutions: lifestyle in the new normal

- Ensuring stable district energy supply and supporting customers' lifestyles with high-level **3E +**
  Comfortable living in the new normal with optimal energy systems and advanced energy management



*1 Vehicle to Home: a system to supply electricity from batteries of EVs (electric vehicles) to home appliances through the distribution switchboard

*2 Virtual Power Plant: Remote and integrated control of distributed energy sources using IoT-based technology for supply-demand balance of electricity

Daigas Group's solutions: C&I sector

- **Providing solutions to various business management issues**, tailored to each customer's needs, with 3D: **Decarbonization, Decentralization, and Digitalization**

Decarbonization

Advanced utilization of gas, energy conservation

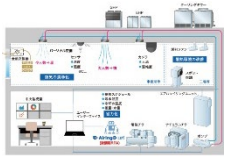
Fuel conversion

CHP (cogeneration)

D-Fire

IoT services for factory energy & labor savings, operation stabilization

D-Airing



Energy control, DX, ventilation tech. for air-conditioning

Utilization of waste

D-Bio

Biomass, such as food waste, to power customer facilities

Biomass boiler

Biogasification

Air-conditioned and ventilated environment

Gas, power, steam

Food residue (waste)

Steam, hot water

Decentralization

Renewable power

Digitalization

CO_2 management and visualization

Emissions reduction with renewable energy

D-Green Power supply service using solar PV

D-Solar Zero-initial cost solar power gen.* service

Supporting customers' emissions management

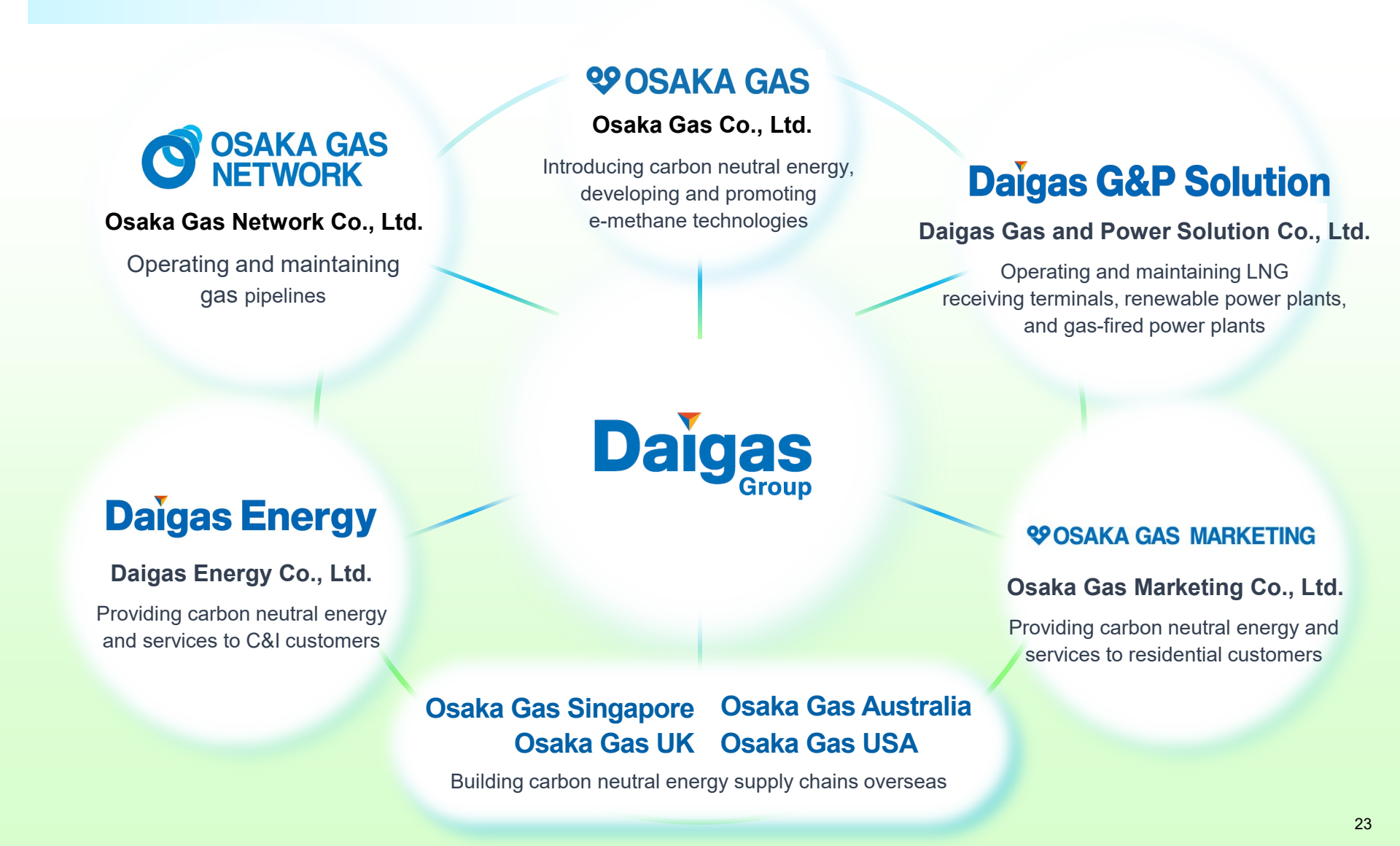
D-Lineup × アスゼロ

One-stop service for company's supply chain emissions visualization and reduction, etc.

* For customer's self power consumption

Daigas Group companies' roles in energy transition

- **Taking the lead in energy transition** and **leveraging the Group's strengths to contribute to achieving a carbon neutral society** through energy supply



[Reference] Renewables 1. Biomass

- Biomass power capacity development in Japan through **early participation** ⇒ 450 MW (8 sites)
- Green Power Fuel Co., Ltd. for **long-term, stable supply of local biofuel for local use in Japan**

Biomass power

Hirohata (75 MW)
Under construction

Tokushima Tsuda (75 MW)
Under construction

Hyuga (50 MW)
Under construction

Ichihara (50 MW)

Sodegaura (75 MW)
Under construction

Aichi Tahara (75 MW)
Under construction

Matsusaka (2 MW)
using locally sourced wood

Gobo (50 MW)
Under construction

Note: Figures in parentheses are the installed capacity of the entire power plant.

[Reference] Renewables 2. Wind

- **Wind power capacity development onshore and offshore** through early participation
  ⇒ onshore: 220MW (10 sites*),
  offshore: under construction off the coast of Goto City, Nagasaki Prefecture

Offshore

Several feasibility studies underway

Goto offshore (Max. 17 MW)
Under construction

Onshore

Shiribetsu (27 MW)

Yokohama Town (43 MW)
Under construction

Noheji Mutsuwan (40 MW)

Inami (26 MW)

Onshore
(more than 10 years in operation)

Hirao (9 MW)

Hirogawa Myojin-yama (16 MW)

Yura (10 MW)

Hayama (20 MW)

Hizen/Hizen South (30 MW)

Note: Figures in parentheses are the installed capacity of the entire power plant

[Reference] Renewables 3. Solar PV

- Solar PV businesses: **Large- and medium-scale development, small-scale services**
- Procuring **~310 MW** of solar PV **at more than 100 sites nationwide**

Solar PV

(Major projects)

- **Misawa** (10 MW)
- **Shizukuishi** (25 MW)
- **Komatsu** (13 MW)
- **Torishima/Torishima Ⅱ** (3 MW)
- **Shouou** (1 MW)
- **Daigas Oita Mirai Solar** (27 MW)
- **Kuwaharajou Mega Solar No.4** (12 MW)
- **Nekko-machi** (12 MW)
- **Isoharacho** (35 MW)
- **Haru Mito** (9 MW)
- **Nabari Kintetsu Gas Yawata** (1 MW)
- **Hirogawa Myojin-yama** (1 MW)
- **Yura North/South** (2 MW)

Home solar PV

137 MW

(34,000 households)

Procurement of Renewable energy 310MW

Note: Figures in parentheses are the installed capacity of the entire power plant


Daigas
Group