Development of Environmental Technology

Principle and Outline

The Daigas Group views technology as the foundation for its corporate competitiveness and views research and development as one of its most important strategies for differentiating itself from the competition. While accelerating low-carbon transitions through development of technologies contributing to the reduction of CO_2 emissions, we take on the challenge of technical research and development for the carbon neutrality of our gas and electricity. We will actively tackle a wide range of subjects, from the advanced use of natural gas to the further utilization of renewable energy and the research and development of carbon-neutral gas technologies such as methanation, to accelerate development of technologies that will contribute to achieving carbon neutrality.

Development of New Technologies that Contribute to Carbon-Neutral Solutions

The Daigas Group believes that “e-methane,*” which is synthesized from hydrogen produced using renewable energy and CO_2, is the key to making city gas carbon-neutral. The Group is working on establishing a variety of methanation technologies toward full-scale introduction of “e-methane” in 2030. Moreover, we are promoting development of technologies that contribute to further low-carbon/carbon-neutral solutions by making use of the gas synthesis/catalyst technology, combustion technology, and material technology that Osaka Gas has developed so far. The Company has developed a variety of natural gas combustion technologies tailored to our customers’ uses, and it is now leveraging that know-how to develop hydrogen and ammonia combustion technologies. Such efforts include development of a small ammonia engine system in cooperation with Toyota Industries Corporation. The Company is also working on the development of chemical looping combustion technology as a technique for producing carbon-neutral hydrogen and electricity from biomass. In addition to energy, Osaka Gas also develops and sells SPACECOOL®, a radiative cooling material. The Carbon Neutral Research Hub of Osaka Gas conducts these research and development projects, disseminates information, and forms business alliances. To further accelerate these efforts, we are establishing a new research and development base in the Torishima district of Osaka City, with full-scale operations scheduled for FY2026.3.

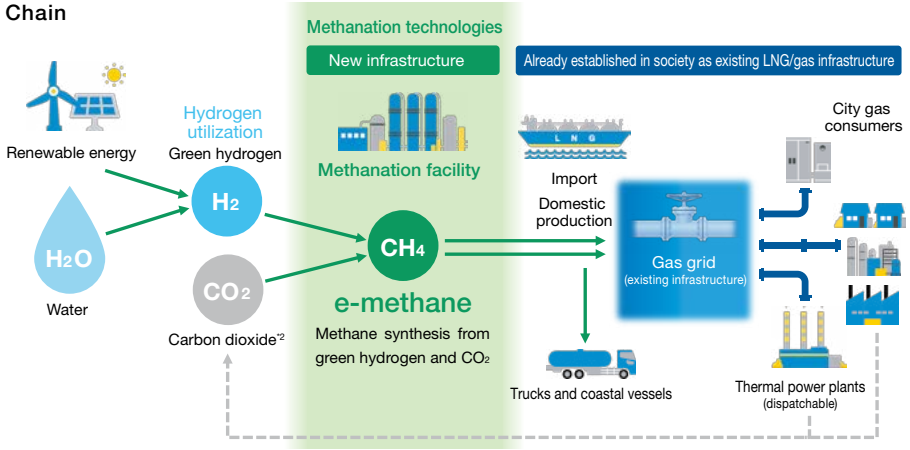
*Synthetic methane produced from non-fossil energy sources, such as green hydrogen, is called “e-methane”.

“e-methane”—the key to carbon-neutral solutions created by methanation technology

“e-methane,” which is produced by recycling CO_2 otherwise emitted into the atmosphere and synthesizing it with hydrogen, is a carbon-neutral hydrogen carrier*1.

Since “e-methane” has almost the same composition as city gas, existing city gas infrastructure and combustion equipment at customers’ sites can be used as is, enabling seamless carbon neutralization during the transition period and advantageously reducing the cost of its social implementation.

■ e-methane Supply Chain



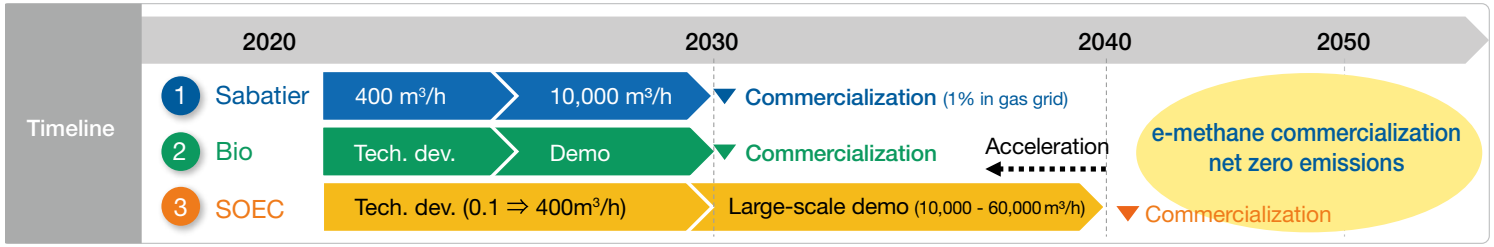
*1 Hydrogen compounds that make it possible to store, transport and use hydrogen efficiently. (Hydrogen is inefficient to store or transport over long distances in its gaseous state.)
*2 Biogenic CO_2 and possibly CO_2 derived from DAC (Direct Air Capture: a technology used to capture and remove CO_2 directly from the atmosphere) might be utilized in the future.
*3 Carbon dioxide Capture and Utilization

Efforts to establish three methanation technologies to enable the introduction of "e-methane"

In addition to working to scale up the existing technology, Sabatier methanation, we aim to commercialize biomethanation, a locally produced and locally consumed energy generation technology, and to achieve early introduction of highly efficient SOEC methanation, an innovative technology.

1. Sabatier methanation*1 (existing technology): Scaled up and implemented in society at an early stage
2. Biomethanation*2 (innovative technology): Produce and use energy locally for local consumption
3. SOEC methanation*3 (Innovative technology): Reduce cost by enhancing energy efficiency

Roadmap for Social Implementation of Methanation Technology



*1 CO_2 conversion by a catalytic reaction with hydrogen derived from renewable energy, etc. to synthesize methane.
*2 Technology that uses biological reactions to synthesize methane from CO_2 and hydrogen
*3 Use of SOEC equipment to electrolyze water and CO_2 into hydrogen and carbon monoxide using renewable energy, etc., and then synthesize methane by catalytic reaction of the hydr ogen and carbon monoxide.

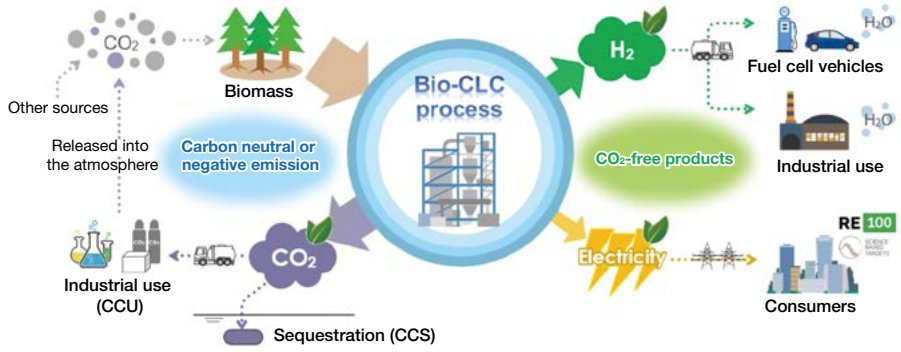
Development of chemical looping combustion technology for simultaneous production of hydrogen, electricity and CO_2

Osaka Gas is working on the development of chemical looping combustion (CLC) technology, which produces hydrogen, electricity, and CO_2 by leveraging the redox action of iron oxide. CLC technology circulates iron oxide to have it react with fuel, water, and air, through which hydrogen, electricity, and CO_2 are produced simultaneously. The fuel may be coal or biomass. When carbon-neutral biomass fuel is used, this technology is expected to produce or supply green hydrogen, electricity, and biomass-derived CO_2.

Meanwhile, there has been no implementation example of CLC technology aimed at producing hydrogen using biomass as fuel. For commercialization, it is necessary to solve technical issues such as elemental technology development toward the establishment of system design technology and process verification.

Osaka Gas aims to utilize this technology to produce and supply green hydrogen using biomass as fuel, helping customers achieve carbon neutrality.

Our Vision for the Practical Application of CLC Technology



Radiative cooling material SPACECOOL®, a new product by SPACECOOL Inc. —Also contributing to realizing a carbon neutral society with world-class cooling performance—

SPACECOOL®, developed by Osaka Gas and manufactured and sold by SPACECOOL Inc., is a radiative cooling material with zero-energy cooling capability. By releasing heat into space under direct sunlight, it lowers the temperature*1 below the outside temperature without using energy. It has the potential of contributing to carbon-neutral solutions for society as a whole.

A demonstration test conducted by Osaka Gas found that the surface temperature of the material was up to about 6°C*2 lower than the outside air temperature under direct sunlight, realizing world-class*3 cooling performance.

The material is available in film, magnet sheet, tarpaulin, etc., and is expected to be deployed as products for implementing measures against global warming, achieving energy conservation and ensuring cooling comfort.

The material was selected for the environmental technology exhibition at the Japan Pavilion of the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28), which was held in Dubai from November 30 to December 12, 2023. SPACECOOL demonstrated the material at physical and virtual exhibitions. This material was exhibited at the COP for the second consecutive year following the previous year. At the exhibitions, people from various countries facing heat issues showed a lot of interest in the material.

It is also expected to be adopted in the Gas Pavilion to be exhibited by The Japan Gas Association at the Osaka/Kansai Expo to be held in 2025, reducing the air conditioning burden in the Gas Pavilion and contributing to lower CO_2 emissions. In the future, we would like to promote the spread of this material both domestically and internationally and contribute to the realization of a carbon neutral society.

*1 This has been achieved by using Osaka Gas's proprietary optical control technology to develop a material design that reduces the solar heat input and increases heat dissipation through thermal radiation.

*2 The temperature was measured at Osaka Gas Energy Technology Laboratories in Konohana-ku, Osaka (ambient temperature at the time of measurement: approximately 35°C). The temperature on the reverse side of a steel sheet covered with the radiative cooling material was measured.

*3 The survey was conducted by Osaka Gas, based on published papers.

Radiative cooling material (thin film material)

Development of technology for predicting solar power generation

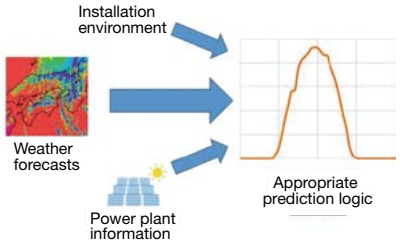
With an eye on the increasing number of solar power plants to realize a carbon neutral society, the Daigas Group is working to develop technology to predict solar power generation and improve the accuracy of the prediction.

Under the previous system, electricity generated in solar power plants was traded at a fixed price, known as FIT. In the future, it is expected that the number of solar power plants operating under schemes other than FIT will increase, as a new purchase method, FIP, has been implemented since FY2023.3. For solar power plants operating under non-FIT schemes, power producers need to predict power generation, and may have risks of paying imbalance costs*. In addition, unexpected fluctuations in the ever-increasing amount of renewable energy may destabilize the grid, leading to the increased risk of power outages. To prevent such incidents from occurring, it will become increasingly necessary to accurately predict solar power generation in advance.

The Group has developed technology to predict weather at a level comparable to that of weather companies, based on our long-accumulated knowledge of fluid analysis. We are implementing highly accurate solar power generation predictions utilizing this technology.

■ Initiatives to improve accuracy

We conducted a comparative analysis of predicted and actual solar power generation at solar power plants throughout Japan by using solar power generation forecast developed by the Osaka Gas Energy Technology Laboratories. As a result, we confirmed high prediction accuracy. We are also working to further improve the prediction accuracy by analyzing and improving the error factors between predictions and actual results.



■ Examples of utilization

Please see 📖P.067 "AI-Based Self-Wheeling Scheme for Renewable Electricity—Starting supply and demand management service for self-wheeling, using a solar power generation system—."

* Imbalance costs: Monetary penalties incurred when there is a discrepancy between the planned and actual amount of electricity generated when operating a solar power plant.

Initiatives to develop the world's first "ultra-long life" storage batteries that last five times longer than current storage batteries

The storage battery market is expected to continue to expand worldwide for multiple applications, such as automotive and stationary use. In Japan as well, storage batteries are positioned as one of the most crucial technologies to achieve the electrification of automobiles and the utilization of renewable energy as the main power source, with a view to achieving the greenhouse gas emissions reduction target for FY2031.3 and carbon neutrality by 2050.

KRI, Inc., one of the Group companies, is a comprehensive private contract research company with both advanced research and development capabilities and consulting functions. The company supports customer businesses by engaging in contract research and analysis evaluation, primarily focusing on energy, environmental technology, and material technology. It also pursues the excavation of new technological seeds and the creation of new value through its own research. In particular, storage batteries are emphasized as one of its key fields of focus, and the company is actively expanding its contract research and development business related to such products. We have been discussing and developing "ultra-long life" storage batteries from two aspects of "materials, electrodes, and batteries" and "diagnosis and operation" with manufacturers who agree on KRI's "ultra-long life concept," with the aim of achieving "ultra-long life," which is the direction of the storage batteries needed for a 2030 society.

Having had the prospect of completing the basic technology for "ultra-long life" lithium ion batteries (LIB)*1 that last five times longer than current storage batteries and reaching its goal, KRI, Inc. plans to start supplying 10Ah (around 400 Wh/L)*2 samples for user evaluation in FY2026.3. The above assumes the use of prototyping and demonstration technology of SEI CORPORATION, which became a subsidiary of KRI, Inc in February 2024.

Ultimately, the company aims to increase the life of conventional 30 kWh batteries installed in electric vehicles (e.g. 160,000 km guaranteed) by more than five times.

*1 A type of storage battery that uses an oxide containing lithium for the positive electrode and carbon material for the negative electrode. This battery has high performance and can be miniaturized. It is used in a variety of applications, including batteries for mobile devices and electric vehicles.

*2 Approximately the capacity installed in an electric motorcycle.