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 decarbonization 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 gas decarbonization technologies such as methanation, to accelerate development of technologies that will contribute to achieving carbon neutrality.

Development of New Technologies that Contribute to Low-Carbon/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.

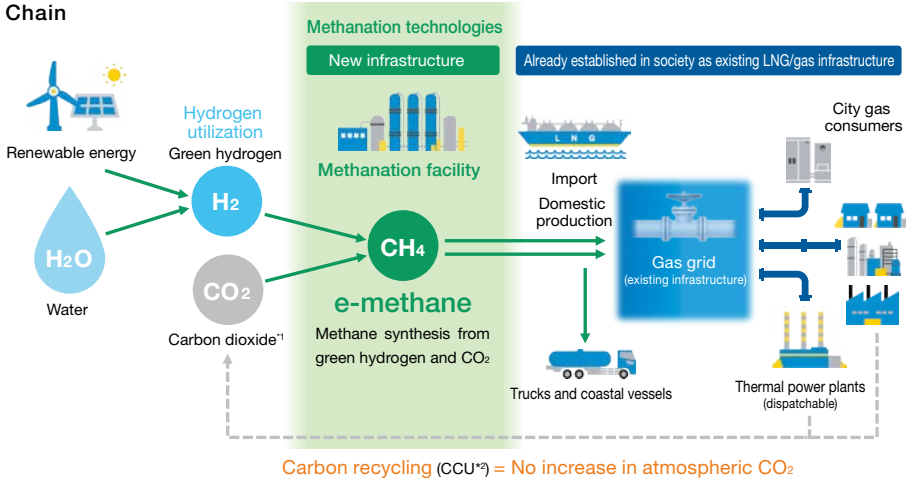
*Synthetic methane produced from non-fossil energy sources, such as green hydrogen, is called “e-methane”.

“e-methane”—the key to low-carbon/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.

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 decarbonization during the transition period and advantageously reducing the cost of its social implementation.

■ e-methane Supply Chain



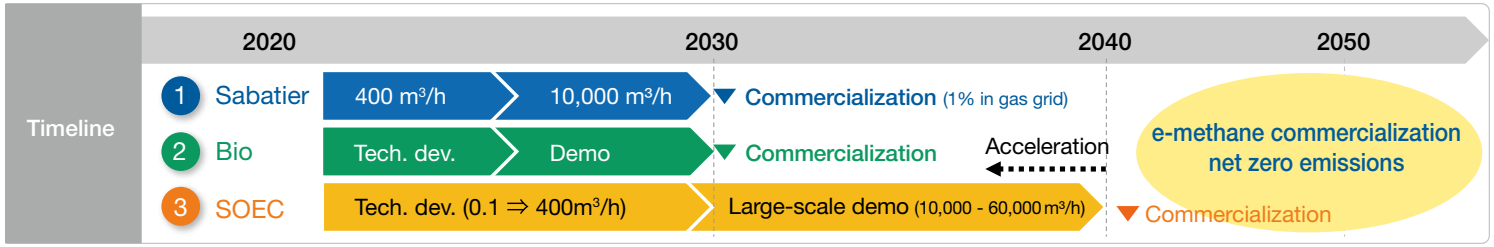
*1 Biogenic CO_2 and possibly CO_2 derived from DAC (Direct Air Capture: a technology used to capture and remove CO_2 directly from the atmosphere) might be utilized in the future.
*2 Carbon dioxide Capture and Utilization

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.

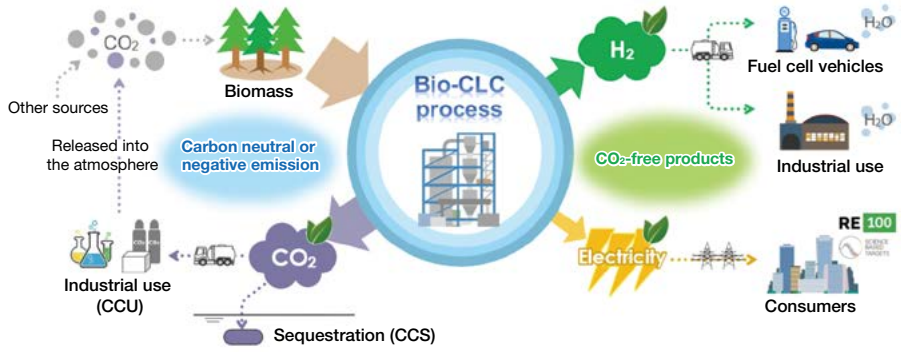
Development of chemical looping combustion technology for simultaneous production of hydrogen, electricity and CO_2

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 decarbonized 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 low-carbon or 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.

Using the material, two types of products (film and canvas) have been developed. The material is expected to be deployed as products for implementing measures against global warming, achieving energy conservation and ensuring cooling comfort. Potential specific applications vary widely, including canvas-covered structures and container warehouses.

The material was selected for the environmental technology exhibition at the Japan Pavilion of the 27th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP27), which was held in Egypt from November 7 to November 18, 2022. SPACECOOL demonstrated the material at physical and virtual exhibitions. At the exhibitions, people from various countries facing heat issues showed a lot of interest in the material.

In the future, we would like to promote the spread of this material both domestically and internationally and contribute to the realization of a low-carbon or 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)