Energy Carriers

Becoming a New Energy Society

Leading the World in Hydrogen Energy Utilization; Creating a Low-carbon, Hydrogen-based Society

Reducing CO_2 emissions is a global issue. But for Japan, a country poor in energy resources, developing renewable energy and new eco-friendly sources of energy comparable to nuclear power is a critical factor to maintain our place as a leader in the international community. Hydrogen Energy looks to be the best candidate for large-scale utilization as a new source of energy. Technology advancements have begun to offer answers to the issues of hydrogen production, transport, storage costs and safety. Now, we are beginning to see concrete results to the initiatives that will put Japan on the forefront as a low-carbon, hydrogen-based society.

Program Director

Shigeru Muraki

Tokyo Gas Co., Ltd.

Advisor

Profile

Shigeru Muraki joined Tokyo Gas Co, Ltd. in 1972. In 2000, he was named general manager of the Gas Resources Department, and in 2002, he was named executive officer and general manager of the Gas Resources Department. Mr. Muraki was subsequently promoted to senior executive officer and chief executive of the Tokyo Gas R&D Division in 2004, and then senior executive officer, chief executive of Energy Solution Division in 2007. In 2010, he was named executive vice president and chief executive of the Energy Solution Division. In 2014, Mr. Muraki was elected vice chairman of Tokyo Gas. He was later named Executive Advisor in 2015 and Advisor in 2017.

Research and Development Topics

1. Develop energy carriers and identify promising candidates

Advance the utilization of liquid hydrogen, organic hydrides, and ammonia as energy carriers for hydrogen production, transport and storage; structure a practical cost model to serve as a foundation for a hydrogen energy value chain.

2. Develop peripheral technologies supporting a low-cost, highly efficient hydrogen value chain

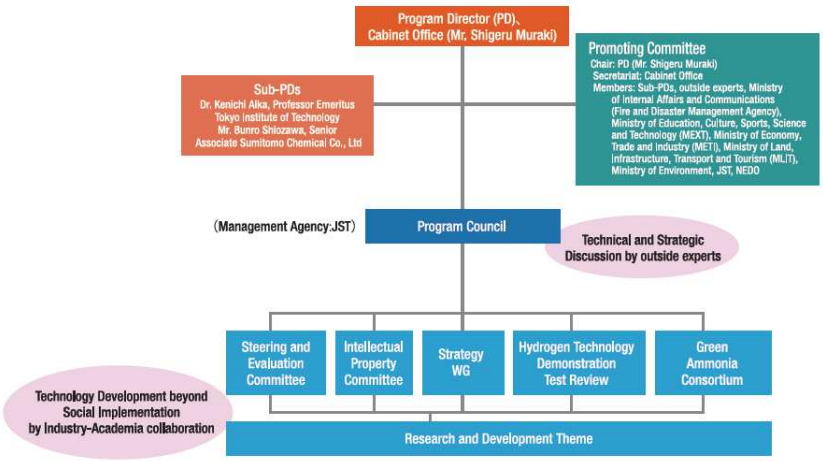
Develop highly efficient hydrogen production technologies using renewable energy. Develop technologies for organic hydride and ammonia production, as well as hydrogen separation. Develop and demonstrate highly efficient technologies for fuel cells, turbines, and engines using hydrogen and energy carriers.

3. Conduct research and development linked to safety standards, deregulation for hydrogen transportation and use

Perform risk assessments for energy carriers, including spill accident simulation analysis and atmospheric diffusion modeling, to collect basic data for approvals and licensing, safety policies, and risk communication.

Implementation Structure

As a program director (PD), Shigeru Muraki is responsible for establishing and promoting research and development plans. The Promoting Committee is chaired by Mr. Muraki with the Cabinet Office serving as secretariat. The Committee is composed of relevant ministries, agencies, and experts who provide overall coordination. The Japan Science and Technology Agency (JST) exercises its authority as the management agency.



Development of technologies related to production, storage, and use of ammonia using CO_2-free hydrogen

We succeeded in the combined verification of ammonia production and power generation using hydrogen derived from renewable energy for the first time in October 2018 as part of our efforts to develop an ammonia production process using CO_2-free hydrogen as a raw material. This process is expected to replace traditional ammonia production using natural gas.
A novel ruthenium catalyst capable of efficiently synthesizing ammonia under a low-temperature and low-pressure environment was developed in addition to an appropriate process for the newly prepared catalyst. Additionally, CO_2-free hydrogen was produced via water electrolysis using electric power derived from solar power generation. Such CO_2-free hydrogen was used as a raw material to produce CO_2-free ammonia in a demonstration test plant customized for the developed catalyst. Furthermore, a power generation test (47 kW) was conducted in a gas turbine using the newly prepared ammonia as fuel to imitate and verify the value chain of CO_2-free ammonia.

•Appearance of the pilot plant for ammonia production

Direct combustion of ammonia

As for the direct combustion of ammonia, the power generation with low NOx concentration (<10 ppm) using 100% ammonia fuel was achieved with the 50 kW class gas turbine, taking into account the characteristics of ammonia, such as the difficulty of ignition and slow combustion speed. The co-firing of ammonia and natural gas with a calorie ratio of 20% ammonia was achieved with a 2 MW class gas turbine for the first time in the world in March 2018, and the viability of the suppression of NOx generation was confirmed.
For the use of ammonia as a fuel in coal-fired power plants, a co-firing test of ammonia with pulverized coal was performed in a large-scale test furnace and proved to be a success with a calorie ratio of 20% ammonia, which is among the best in the world. Moreover, a mix combustion test of ammonia was performed in the Mizushima Power Station Unit No. 2 of Chugoku Electric Power. This test succeeded in power generation by co-firing with 1% ammonia at the coal-fired power plant under real operating conditions.

•Large-scale combustion test plant

Ammonia fuel cell

Associated with the development of technologies for high-efficiency fuel cell systems using ammonia as a fuel, especially for solid oxide fuel cells (SOFCs), the design and manufacture of a prototype 1 kW class direct ammonia supply system for demonstration tests was achieved.
Power generation with a 1 kW class SOFC module, which directly uses ammonia as a fuel, was achieved with a power generation efficiency of 56% for the first time in the world. The achievement of high-power generation efficiency comparable to that of hydrogen-powered fuel cells enhanced the expectations for using ammonia as an energy carrier domestically and abroad. After packaging, automatic activation, development of cracking catalysts, production of reactors, and optimization of power system components, a 1 kW class fuel cell system was developed in May 2018. In the future, we intend to develop large-scale systems, which can serve as a distributed power source in a hydrogen society.

•Appearance of the fuel cell system