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**Tokyo Gas Begins Residential SOFC System Trial Operations  
Under NEDO Solid Oxide Fuel Cell Demonstration Research Project  
~Realizes Large Improvement in Horizontal-stripe Cell Stack Durability~**

Tokyo Gas Co., Ltd.  
Kyocera Corporation  
Rinnai Corporation  
Gastar Co., Ltd.

Tokyo Gas Co. Ltd. (hereinafter referred to as “Tokyo Gas”; Mr. Mitsunori Torihara, President), Kyocera Corporation (hereinafter referred to as “Kyocera”, Mr. Tetsuo Kuba, President), Rinnai Corporation (hereinafter referred to as “Rinnai”; Mr. Hiroyasu Naito, President) and Gastar Co. Ltd. (hereinafter referred to as “Gastar”; Mr. Seiichi Nakanishi, President) are currently engaged with joint development of a solid oxide fuel cell<sup>\*1</sup> system with a horizontal-stripe cell stack power generation module (hereinafter referred to as “this SOFC system”)

From this month, Tokyo Gas has commenced the first trial operations of this SOFC system, as part of the New Energy and Industrial Technology Development Organization (NEDO) “Demonstration Research on Solid Oxide Fuel Cells” project (hereinafter referred to as “the SOFC demonstration research project”).

Compared with conventional systems,<sup>\*2</sup> this SOFC system reduces primary energy consumption by approximately 45% and CO<sub>2</sub> emissions by approximately 55%.

Moreover, the durability of the horizontal-stripe cell stack power generation unit had previously been confirmed up to about one year. By advancing subsequent development works, the latest tests showed that the durability of cell stack bundle<sup>\*3</sup> has now been improved to the equivalent of five years.

\*1. A solid oxide fuel cell (SOFC) is a type of fuel cell which produces electricity and water from a chemical reaction, typically between hydrogen extracted from city gas or other fuels and oxygen in the atmosphere. The cell stack which is the power generation module mostly uses ceramics, and produces electricity at a high temperature of 700°C or higher. Among other advantages, this system surpasses the average thermal power generation efficiency (41% LHV), has the highest power generation efficiency of all fuel cells, can use a small hot water tank because of the high exhaust heat temperature, has a small number of parts,

and is expected to reduce costs.

\*2. The format whereby electricity is supplied from thermal power plants and heat is supplied by conventional water heaters burning city gas supplied by Tokyo Gas.

\*3. The output of a single horizontal-stripe cell stack is approximately 10 watts. Practical electric output is achieved by bundling together multiple cell stacks and connecting them electrically. These bundled cell stacks are called cell stack bundles, and these bundles are the units that are incorporated into the SOFC system.

#### ■ SOFC Demonstration Research Project Trial Operations

The SOFC demonstration research project is being implemented over four years from FY2007 through FY2010 to identify the future technological development issues by installing SOFC systems in regular households and at other locations, operating them under actual power loads, collecting empirical data, and conducting evaluation analyses.

From this month, Tokyo Gas has commenced trial operations of this SOFC system at two single-family homes, one in Yokohama City (Kanagawa Prefecture) and the other in Kokubunji City (Tokyo). Tokyo Gas plans to conduct trial operations on four additional units from FY2010, and to collect data from a total of six units.

Tokyo Gas is implementing these trials to operate this system under actual power loads, verify durability and reliability, and use the issues identified for future development works. The company plans to commercialize this system by early 2010s by further improving the power generation efficiency, making the system more compact, and realizing a projected durability of 10 years for both the cell stack and the system.

#### ■ System Installed for the SOFC Demonstration Research Project

This system comprises the horizontal-stripe cell stack power generation unit and a hot water storage unit for efficient use of the recovered exhaust heat. The development works for both of these units are primarily being advanced by Tokyo Gas, Rinnai and Gostar.

To gain the maximum performance from the horizontal-stripe cell stack, the power generation unit is made compact to regulate the heat radiation loss and designed to optimize the internal temperature distribution and the fuel and air flow distribution.

Considering energy conservation and environmental load, the “Eco-Jozu”<sup>\*4</sup> high efficiency water heater, which recovers latent heat, has been adopted for the hot water storage unit as a supplementary heat source. The hot water storage unit is exclusively designed to work with the power generation unit.

The power generation and hot water storage units both incorporate control systems for safe and easy use, assuming trial operations at actual residences. They also feature compact design for installation in crowded urban areas.

\*4. “Eco-Jozu” is a high-efficiency water heater which improves the hot water supply efficiency from around 80% to around 95% by recovering exhaust heat which was previously wasted.

#### ■ Approach to Improving the Durability of the Horizontal-stripe Cell Stack

The horizontal-stripe cell stack development is being advanced by Tokyo Gas together with Kyocera. Structurally, multiple single cells, which are the smallest units of the power generation module, are sintered on a single ceramic substrate, with the cells connected on the substrate in a series. Lower costs are expected under mass production because inexpensive insulation materials are used for the substrate, which comprises most of the cell stack.

The horizontal-stripe cell stack development has focused on extending durability, which is one important point for commercialization. These efforts have combined the horizontal electrode configuration designed by Tokyo Gas with Kyocera’s materials and manufacturing technologies. The durability has been extended by revising the detailed design, developing components, improving manufacturing technologies, and devising all-ceramic cell stack technologies, which avert the use of alloy materials that might affect durability. The works have also incorporated numerous technological improvements, such as developing materials that can control electrode degradation even after long-term power generation.

Electric-furnace durability tests on cell stack bundles, which bundle together multiple cell stacks, have confirmed that the cell stack durability has now been extended to the equivalent of five years.

#### ■ Horizontal-stripe SOFC Development History

The four companies Tokyo Gas, Kyocera, Rinnai and Gastar initiated development of an industrial power generation unit toward early commercialization of SOFC systems from February 2004.

From FY2007, the companies changed the application field to residential use and expanded the range of the development works from the power generation

unit to the entire cogeneration system.

In the current division of works, Tokyo Gas and Kyocera are responsible for the development of cell stack bundles, while Tokyo Gas, Rinnai and Gastar are responsible for the development of the power generation unit and the hot water storage unit.

■ System Specifications

Power Generation Unit

Power output	700W
Power generation efficiency	42%LHV
Exhaust heat recovery efficiency	35%LHV
Dimensions (unit: mm) ( W × D × H)	650 × 350 × 1040

Hot Water Storage Unit

Tank capacity	80L
Water heater	Latent heat recovery type model 24
Dimensions (unit: mm) ( W × D × H)	890 × 350 × 1620

Tokyo Gas, Kyocera, Rinnai and Gastar will continue diligently advancing development works toward the early commercialization of SOFC systems for the realization of a low-carbon society.