

Commercialization of a residential PEM Fuel Cell CHP "ENE FARM"

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Abstract

Proton Exchange Membrane fuel cell (PEMFC) based residential CHP fueled by natural gas has been developed by Japanese Gas Utilities from around 2000. And from JFY 2005 to JFY 2008, over 1,300 natural gas residential PEMFC CHP systems were demonstrated in the Large Scale Stationary Fuel Cell Demonstration Project conducted by NEDO*¹ subsidized by METI*². In the project superior performances of the systems, such as 23% reduction in primary energy use and 38% reduction in CO₂ emission, were demonstrated in actual use at real households.*1: New Energy and Industrial Technology Development Organization, *2: Ministry of Economy, Trade and Industry

Encouraged by the satisfactory result, Tokyo Gas and Osaka Gas stepped for commercialization of respective residential PEMFC CHP system with their joint development partners such as Panasonic, Toshiba Fuel Cell Power Systems (Toshiba FCP) and so on. Intensive development activities were conducted aiming higher reliability, longer lifetime, easier installation and maintenance, improved remote control device and lower cost without sacrificing the superior performance demonstrated in the Large Scale Demonstration Project.

As a result of the development, the both companies successfully released their respective commercial model of residential PEMFC CHP systems with a trade name "ENE FARM" in the spring of 2009. And the ENE FARMS were released from the other Japanese natural gas utilities too.

Each model of ENE FARM, whose rated power is from 0.7 to 1 kW, generates power and hot water for domestic use efficiently with electrical efficiency of over 35 % and overall efficiency of over 80 %. With the high performance, large reduction in primary energy consumption is expected. Counting their superior performance, METI has started subsidization for the customers who install the system in order to promote the market penetration of the residential PEMFC CHP systems from JFY 2009.

Over 7,700 natural gas ENE FARMS were sold in about two years from their launch to the end of March 2011. And the number of sales contract of ENE FARM in three months from April to June 2011 is approaching 5,000.

1. Basic technology development

PEMFC, a kind of fuel cell, is a technology that can generate power efficiently with very low environmental impact (clean exhaust, low noise and vibration etc.) in very small scale such as sub-kW class using hydrogen as its fuel. Although PEMFC is operated at relatively low temperature or 60 to 80 deg C, its waste heat can be recovered as hot water useful in households.

Counting these features, Tokyo Gas and Osaka Gas proposed a concept of highly efficient residential CHP system using PEMFC combined with natural gas fuel processor, and the Japanese Gas Utilities including both companies started development program respectively from around 2000. Schematic of a residential PEMFC CHP is shown in Fig.1.

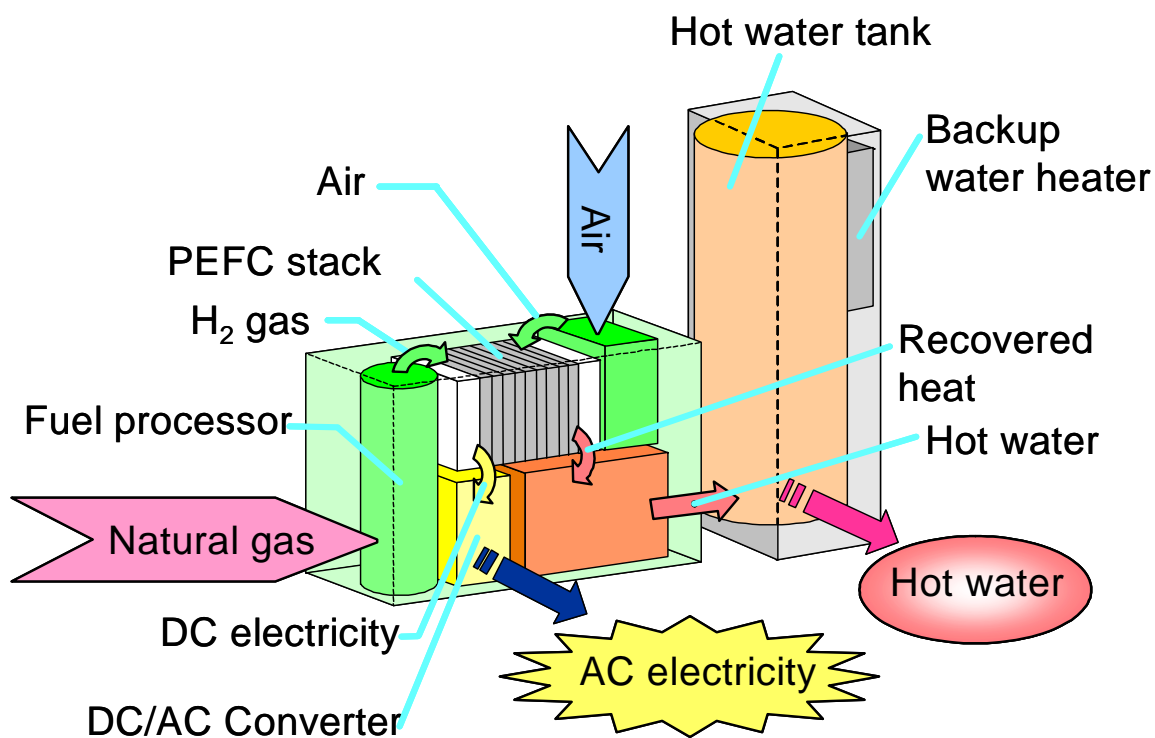


Fig.1 Schematic of a residential PEMFC CHP

Many basic technical barriers, including highly efficient and compact natural gas fuel processor, durability of the PEMFC stack and the fuel processor against frequent start and shutdown without nitrogen as protective inert gas, intelligent operation control to achieve maximum energy efficiency in real household, were overcome in the early stage of their development program with PEMFC manufacturers.

And in parallel many barriers related to regulation were also overcome by cooperation of Japan Gas Association, PEMFC manufacturers and other energy industries such as oil and LPG.

Tokyo Gas and Osaka Gas played a main role in these activities.

As a result, PEMFC CHP systems 23% reduction in primary energy use and 38% reduction in CO₂ emission as an averaged data of the best performance model in the Large Scale

Stationary Fuel Cell Demonstration Project. The project was a program conducted by NEDO subsidized by METI to test a large number of PEMFC CHP systems at real households from 2005 to 2008.

2. Commercial product development

Encouraged by the satisfactory result from the Large Scale Stationary Fuel Cell Demonstration Project, Tokyo Gas and Osaka Gas stepped for commercialization of respective residential PEMFC CHP system. Tokyo Gas teamed with Panasonic and Osaka Gas teamed with Toshiba FCP and ENEOS Celltech respectively.

Performance of PEMFC CHP systems at the project was superior, but many issues, such as higher reliability (Reduction of troubles), longer lifetime, easier installation, easier maintenance, improved remote control device and lower cost, still remained and intensive development activities were conducted for each issue.

1) Reliability

In order to reduce troubles, design was improved based on the analysis of troubles of the past models and prototypes.

2) Lifetime

Durability of PEMFC stack and fuel processor those decide lifetime of the system was greatly improved by intensive R&D in the academia and the fuel cell industry. But for commercial release, methods to confirm their lifetime in shorter time were necessary too. Both companies established the methods with their joint development partners as a result of intensive R&D. As a result, targeted lifetime was established.

3) Installation and maintenance

Shortening the time and reducing the hands for installation and maintenance is also very important. Workers engaged in installation or maintenance of usual domestic gas appliance checked prototypes. Design was improved by their advices.

4) Remote control device



In order to improve users' satisfaction, the information displayed at the remote control device was enriched in terms of power generation, recovered heat usage, CO₂ reduction and so on.

5) Cost

In addition to the cost reduction of major components such as PEMFC stack and fuel processor, simplification of system configuration contributed to reducing cost. Some BOP (balance of plants) components from NEDO project that developed BOP components based on the unified specification by Japanese residential PEMFC manufacturers were adopted.

As a result of these efforts, Tokyo Gas and Osaka Gas have successfully developed and released respective commercial products of PEMFC CHP system keeping superior performance. Their specifications and appearance was shown in Table 1.

Table 1 Specifications and appearance of PEMFC CHP released in 2009

		Tokyo Gas / Panasonic	Osaka Gas / Toshiba FCP (TSB) Osaka Gas / ENEOS Celltech(EC)
Fuel type		LNG based natural gas (category 13A)	
Fuel cell unit	Max. output	1 kW	0.7 kW
	Min. output	0.3 kW	0.25 kW
	Electrical efficiency	37 % LHV	35 % LHV
	Heat recovery efficiency	52 % LHV	45 % LHV
	Dimensions	W780 D 400 H 860 mm	W890 D300 H 895 mm (TSB) W900 D350 H 900 mm (EC)
	Dry weight	125 kg	105kg
Hot water storage unit	Dimensions	W 750 D 480 H 1883 mm	W 750 D 440 H 1900 mm
	Dry weight	125 kg	105kg
	Tank capacity	200 L	200 L
List Price		3.465 million yen	3.255 million yen
Appearance			

3. Market development

The Japanese residential PEMFC industry determined a common brand name called “ENE FARM” prior to its commercial launch by a proposal of Tokyo Gas and Osaka Gas. It contributes to improvement of public recognition of residential PEMFC CHP.

Besides, both companies established their own system for installation and maintenance in order to penetrate ENE FARM smoothly.

And ENE FARMS developed by both companies were released by the other Japanese natural gas utilities too.

Counting the superior efficiency of ENE FARM, METI has started subsidization for customers who install the system in order to promote the market penetration of the residential PEMFC CHP systems from JFY 2009. Amount of subsidy was 1.4 million yen in JFY 2009 and 1.3 million yen in JFY 2010 for a system at the maximum.

As a result, Over 7,700 natural gas ENE FARMS developed by both companies were sold in about two years from their launch to the end of March 2011.

Although METI's subsidy has been decreased to 1.05 million yen from April 2011, the sales of ENE FARM are favorable. The number of sales contract of ENE FARM is approaching 5,000 in only three months from April to June 2011.

Tokyo Gas and Osaka Gas will continue to make efforts to improve and promote ENE FARM. For example, in April 2011 Tokyo Gas and Panasonic released improved model with higher efficiency (40 % in electrical efficiency), lower price (ca. 2.76 million yen) and smaller installation space requirement (2 m², about half of the previous model).

The residential PEMFC CHP, ENE FARM, is expected to improve primary energy consumption, reduce CO₂ emission and expand the natural gas sales in residential area by its market penetration because of its high efficiency in Japan and in all over the world by adjusting to the foreign market in the future. And this will greatly contribute to the growth of world gas industry.