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Commercialization of Residential PEFC Cogeneration System

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1. Abstract

Tokyo Gas has developed with Panasonic a new model of its residential PEFC (Polymer Electrolyte Fuel Cell) cogeneration system, Ene-Farm. The system is available in the market from 1st April 2011. After the successful world's first market entry of residential PEFC systems thorough "the Large Scale Demonstration Project"(2005-2008) conducted by NEF(※1)/ NEDO(※2) and supported by METI(※3), Tokyo Gas released its first commercial model of a residential PEFC system in 2009 by the name of "Ene-Farm" which is a common trademark in Japan. Approximately 4,000 systems were sold in two years and their high performance and user-friendly interface satisfied its customers. Being based on the honored first model, the new model has been developed in order to add various improvements such as better electrical efficiency, smaller installation space, reduced cost, better user-interface and so on.

※1 NEF (**N**ew **E**nergy **F**oundation) ※2 NEDO(**N**ew **E**nergy and Industrial Technology **D**evelopment **O**rganization) ※3 METI(**M**inistry of **E**conomy, **T**rade and **I**ndustry)

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2. Body of Papers

2.1. Market development of residential PEFC cogeneration system, Ene-Farm

2.1.1. Sales results of Tokyo Gas

From 2005 to 2008, Tokyo Gas participated in the Large-scale demonstration project.
During the period, about 1000 PEFC cogeneration systems were installed and tested in actual households. Findings from the project were reflected in the development of the next models. Thanks to these efforts, Tokyo Gas succeeded in the commercialization of the residential PEFC cogeneration system named Ene-Farm for the first time in the world (hereafter, called “first model”). About 4000 systems of the first model were installed from 2009 to 2010 by Tokyo Gas. Meanwhile, 10000 systems of Ene-Farm were installed throughout Japan. Tokyo Gas has had the highest market share.

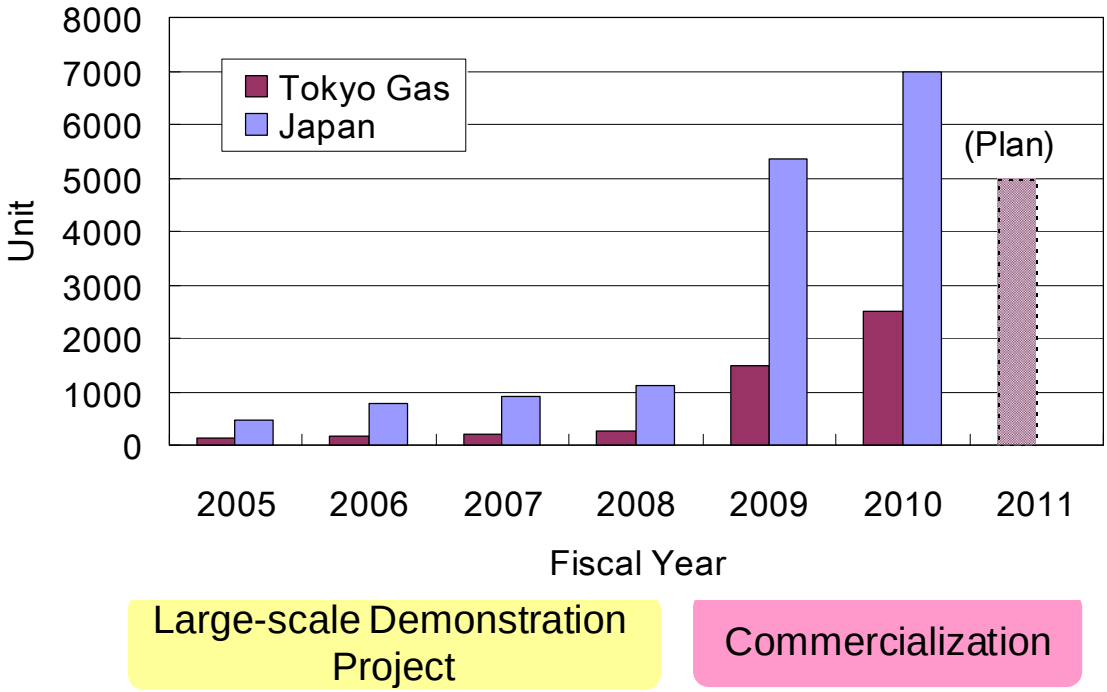


Fig 1: Sales results of Ene-Farm

2.1.2. Issues from the first model of Ene-Farm

Tokyo Gas is investigating the evaluation of the first model by its customers. The investigations show that the first model, which demonstrates high performance by its operation data, doesn’t meet some customer’s high expectations to the following items.

- Reduction of an electricity and a gas bill
- Making electricity and hot water efficiently

Another issue is the installation space. There was sometimes the case that customers who want to install an Ene-Farm cannot install it because there was no room enough for installation.

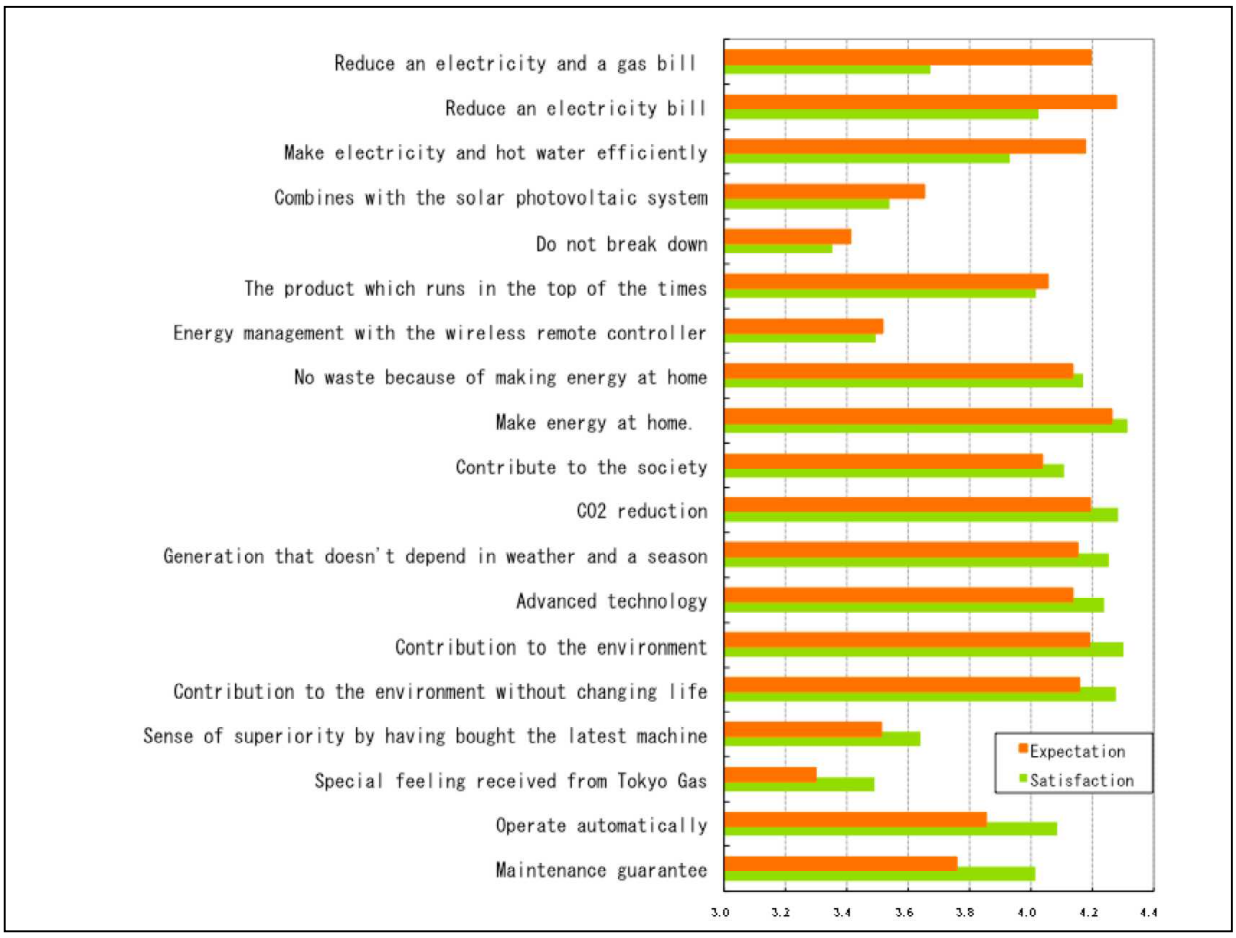


Fig 2: Evaluations of the first model by its customers

2.1.3. Development target of the new model

We set the development targets of the new model based on the issues from the first model. The targets are as follows.

- Cost reduction
- Higher performance
- Smaller installation space
- Improvement of user interface

After three years development toward these targets, the new model was released in April, 2011.

2.2. Specifications and improvements of the new models

2.2.1. Specifications

As well as the first model, the new model was developed jointly with Panasonic. Table 1 shows the specifications of the new model, listed with those of the first model.

In the new model, the rated power and minimum power is decreased in order to give primary energy saving merits to customers with small energy demand. By making the height and the depth of the fuel cell unit and the hot water storage unit the same, all-in-one design installation become possible by connecting them.

Table 1: Specifications of the first model and the new model

		First model	New model
Fuel type		LNG based natural gas (category 13A)	
Fuel cell unit	Max. output	1kW	0.75kW
	Min. output	0.3kW	0.25kW
	Electrical efficiency	37 % LHV/33 % HHV	40 % LHV/36% HHV
	Heat recovery efficiency	52 % LHV/47 % HHV	50 % LHV/45 % HHV
	Heat recovery temperature	60 ˚C	
	Dimensions	W780 D 400 H 860 mm	W315 D480 H 1883 mm
	Dry weight	125 kg	100kg
	Fuel consumption rate	3.0kW HHV	2.1kW HHV
Hot water storage unit	Dimensions	W 750 D 480 H 1883 mm	
	Dry weight	125 kg	
	Tank capacity	200 L	
	Backup burner input	64.7kW HHV	
Appearance			 connected all-in-one design installation

2.2.2. Cost reduction

Cost reduction not only of the system itself, but also of the installation and the maintenance.

About the cost reduction of the system, all the components of the system, including the FC stack and the fuel processor, were re-designed or re-selected from scratch to reduce manufacturing cost. The costs of the pumps, valves, fans and the other balance of plant (BOP) were reduced thanks to a NEDO project, in which all major PEFC system manufacturers in Japan try to unify their spec requirements for each component aiming cost reduction by mass-production effect. By the approaches mentioned above, about 0.7 million yen cost reduction at the fixed price of the system was achieved.

As mentioned in 2.2.1, the new model can be installed in connected all-in-one design. In this installation,

because the position of the piping between both units is completely fixed, the ready-made heat collection piping parts is available. So the piping processing work on the site becomes unnecessary, and as a result, the labor cost for installation can be reduced. In addition, the price of a pre-cast base has been decreased by adopting a new manufacturer, which is skillful in manufacturing a small pre-cast base and the efficiency improvement of the manufacturing process.


Fig 3: Pre-cast base for Ene-Farm

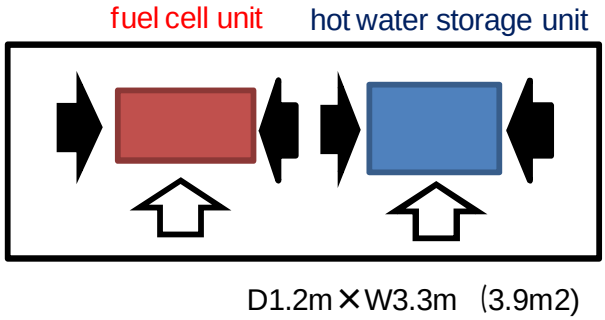
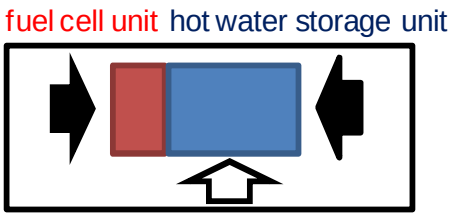
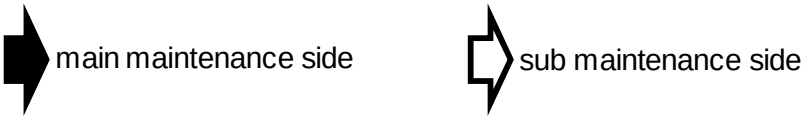
The interval of the new model's regular maintenance is about 2.5 years (three times in 10 years' use), whereas the first model's is about 1 year (nine times in 10 years' use). In addition, we decreased the number of the regular maintenance parts from 9 parts (first model) to 6 parts. Thanks to these approaches, the maintenance cost is reduced.

2.2.3. Smaller installation space

In the metropolitan area of Japan such as Tokyo, there is not so large space for installation of Ene-Farm. In some case, we had to give up installation of the first model. So we tackled to decrease the installation space necessary for the new model.

First of all, because maintenance from only one direction is enabled by reviewing the component placement of the new model, the depth size necessary for the installation has been reduced. Next, the space between both units became unnecessary by achieving connected all-in-one design installation, and the width size necessary for the installation has been reduced. The installation space necessary for the new model is 2.0m2, which is about half of that of the first model.

Table 2: Installation space necessary for Ene-Farm

First model	New model
	
	

2.2.4. User-friendliness

Electricity and heat are too essential for people to realize that they are valuable. If a cogeneration supplies power and heat without offering information, people, especially domestic consumers, will not notice its real value. That is why the user-interface is strengthened. In Japan, most of recent hot water heaters have their control devices on the wall of the living room and the bathroom, which are rather simple and display the temperature of hot water only. But the control device of the new model is aimed to give enough information to the user and thus able to display how much electricity and hot water are/were generated, how long the system has operated, when it will start power generation of the day and how much the user did contribute to the CO2 emission reduction. Furthermore, the user can select power generation modes, by which he or she determines more actively when and how much the system operates. In the new model, we enlarged the display of the control device by 76% compared with that of the first models, and realized easily viewing and comprehensible content.

Table3: Appearance of the control device

First model	New model
	

2.2.5. Durability

The new models can generate electricity for 50000 hours or 4000 start/stop cycles, where the first model can for 40000 hours or 4000 cycles. The durability of each component was verified by the data of accelerated stress tests, continuous tests, start/stop tests or actual records.

2.3. Operating results of the new model

Figure 4 and 5 show the daily data of a new model obtained from load pattern test in the laboratory, in comparison with the yearly averaged data of the first models in the actual households.

Figure 4 shows electrical efficiency of the new model and the first model. The new model is higher than the first model in the electrical efficiency.

Figure 5 shows the primary energy savings of the new model and the first models. The primary energy savings of the new model grows as the hot water demand grows, which is the same tendency with that of the first model. The primary energy savings of the new model is about the same level as that of the first model.

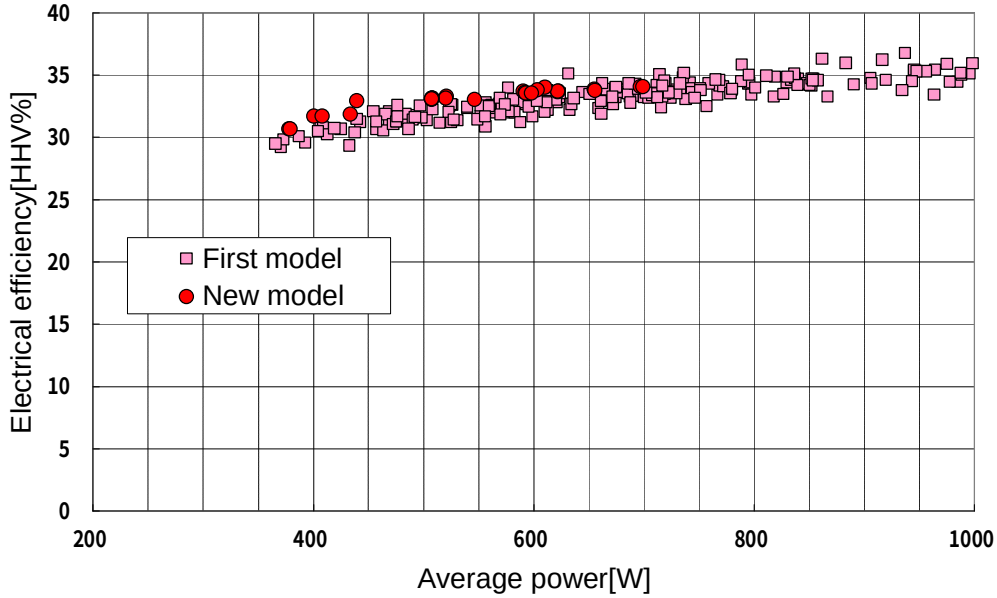


Fig 4: Electrical efficiencies of the first/new models

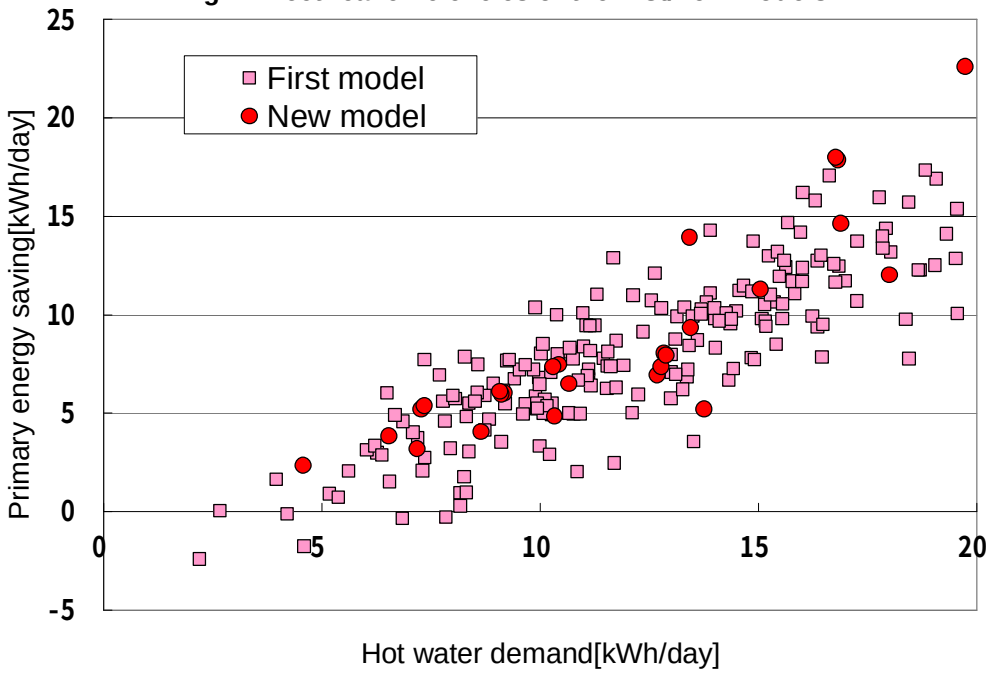


Fig 5: Primary energy savings of the first /new models

2.4. Summary

・Tokyo Gas succeeded in developing the new model of its residential PEFC cogeneration system, which went on sale in April 2011.

・The new model is designed to be cheaper, to have smaller space for installation, to have a user-friendly interface.

・It is verified that the new model has a better electrical efficiency than the first model which was already very good at reducing the primary energy consumption.

2.5. Acknowledgement

Our deepest appreciation goes to METI, NEDO and NEF for their continuous support to development and introduction of Ene-Farm.

3. References

1) Yusuke Ito, “Performance of New Residential PEFC Cogeneration Systems”, Tokyo Gas Co., Ltd.,2009

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