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Development of residential 700W PEFC micro-CHP system

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1. Abstract

Residential Polymer Electrolyte Fuel Cell (PEFC) micro-CHP system is an energy efficient power generation device that can also utilize waste heat in the process of power generation. Therefore, it is capable for a typical Japanese family to reduce CO2 emission by 1.4 ton per year, as well as to save approximately 20% of their energy cost.

Osaka Gas has been developing this PEFC system since 1999, and developed its fuel processing system in 2003. After 5-year joint development with Toshiba Fuel Cell Power Systems, Osaka Gas commercialized 700W PEFC micro-CHP system “ENE-FARM” in June 2009. Its accumulated sales volume exceeded 20,000 as of March 2014, and its sales have been increasing steadily, partly owing to the model change of April 2012.

We have continued further development of ENE-FARM to spread widely, and the new model was released in April 2014. For this model, various improvements, such as reduction of system cost, increase of system efficiency, reduction of installation space, reduction of test run duration, and adoption of the remote controller with a built-in wireless LAN module, and so on, are applied.

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2. Paper

2-1 Concept of residential cogeneration system

Residential cogeneration system is an energy efficient power generation device that can also utilize waste heat as hot water in process of power generation. Osaka gas released the “ECO-WILL” that is world‘s first 1kW-class gas engine cogeneration system for residential market in March 2003. The total sales are over 85,000 units so far. We have created the market for residential cogeneration system.

Figure.1 shows the basic concept of the residential cogeneration system. Power generation unit generates electricity, and its electric power is grid-connected and supplied to electronic appliances. On the other hand, exhaust heat recovered as hot water, is once stored in a storage tank, and then used for hot water supply and floor heating. This system is equipped with a back-up boiler to supply hot water, in case the amount of hot water in the tank is not sufficient.

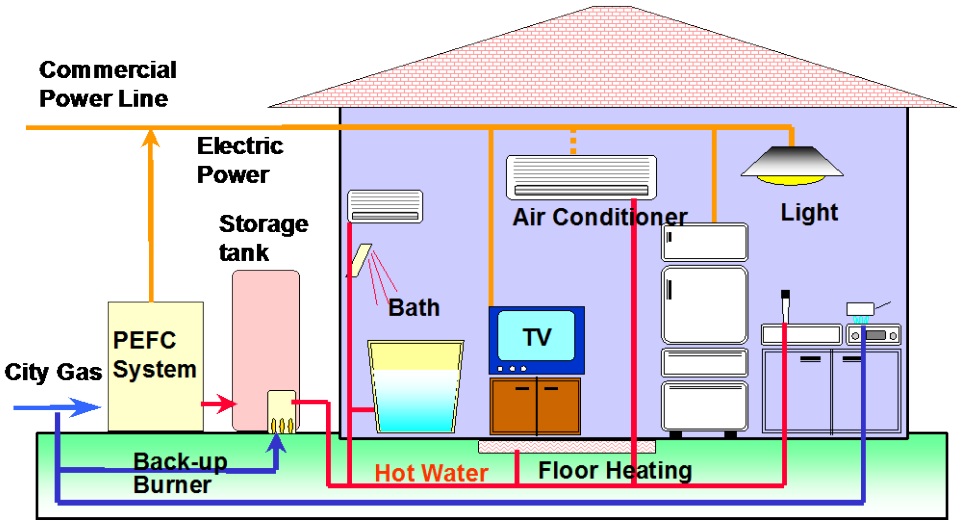

Fig.1 Concept of cogeneration system for residential application

2-2 Background of developing PEFC cogeneration system at Osaka Gas

Polymer Electrolyte Fuel Cell (PEFC) cogeneration system has a potential to achieve higher power generation efficiency than gas engine system. Therefore, Osaka Gas has focused on the development of PEFC system among cogeneration systems[1)].

Figure.2 shows background of developing PEFC cogeneration system at Osaka Gas. We have been developing this PEFC system since 1999, and completed its fuel processing design in 2003[2), 3), 4)], and in the same year, we started joint development with Toshiba Fuel Cell Power Systems. In 2005, we participated in the “large-scale demonstration project”, which Japanese government promoted from 2005 to 2008. Then, Osaka Gas commercialized 700W PEFC micro-CHP system “ENE-FARM” in June 2009.

After 3-year development with Toshiba, 2nd model was released in April 2012.

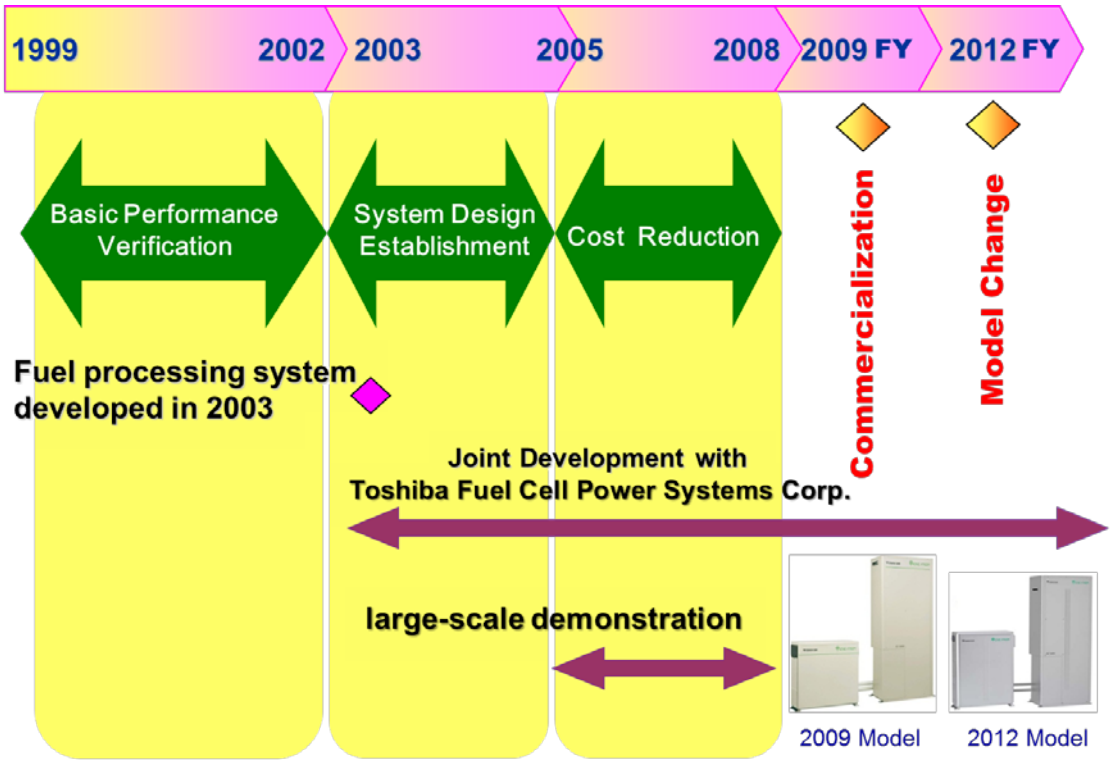

Fig.2 Background of developing PEFC cogeneration system at Osaka Gas

Figure.3 shows transition of the sales volume of ENE-FARM by Osaka Gas. The sales volume has been increasing every year since 2009, and accumulated total volume broke through 20,000 units in 2013, partly owing to the model change in 2012.

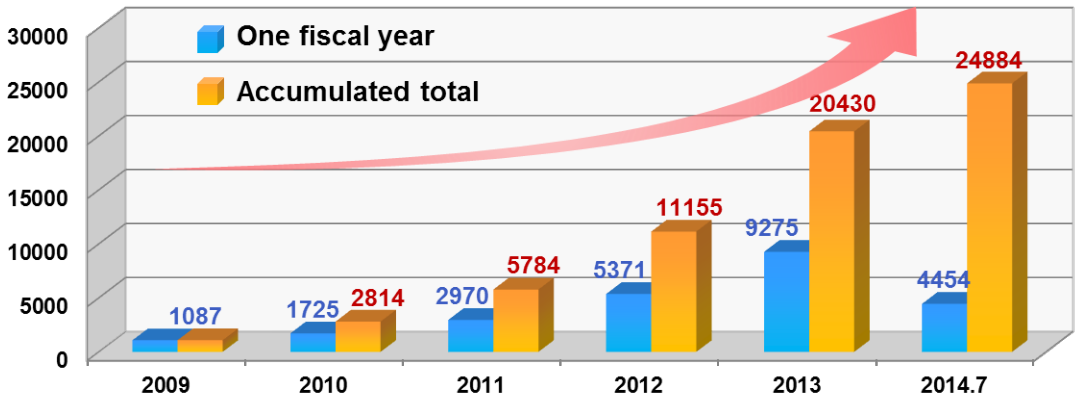

Fig.3 Transition of the volume of sales

However, in order to spread ENE-FARM as a normal commodity, it is required to reinforce the system marketability. Therefore, Osaka Gas has continued the joint development with Toshiba, and a new model, which becomes the third generation, is to be released in April 2014.

2-3 Features of new model ENE-FARM

2-3.1 Specifications

Figure.4 shows the appearance of the new model, and table.1 shows the main specifications of this model.

Power output range is 250-700W. Power generation and heat efficiencies improved 0.5 point respectively, and its total efficiency was improved to 95% (LHV) from 94% (LHV). As for the installation space, the required distance from wall was reduced from 790mm to 700mm. The acoustic noise was reduced to 37dB or less, in all direction, both by the vibration control of components and by blocking a leakage of the sound from package. Unit price decreased by 25% from conventional model. This is mainly attributed to employment of low cost cell stack materials, simplification of reformer structure, and reduction of system components.

Fig.4 Appearance of the new model

Table.1 Specifications of the new model and the conventional model

		New model	Conventional model
Release date		2014/4/1	2012/4/2
Performance	Power output range	250W～700W	
	Electrical efficieny (LHV)	39.0%	38.5%
	Total efficieny (LHV)	95.0%	94.0%
Demension	Fuel cell unit	W780×H1,000×D300 (mm)	
	Hot water storage unit (made in Chofu)	W750×H1,760×D440 (mm)	
Dry weight	Fuel cell unit	94kg	94kg
	Hot water storage unit (made in Chofu)	92kg	100kg
Installation space		distance from wall 700mm	distance from wall 790mm
Acoustic noise	Fuel cell unit	37dB or less in all directions	38dB or less in all directions
List price		JPY 1,944,000	JPY 2,604,000

2-3.2 Improvement of system efficiency

Figure.5 shows power generation efficiency and Figure.6 shows total efficiency. Power generation efficiency was improved from 38.5%(LHV) to 39%(LHV), and total efficiency was improved from 94%(LHV) to 95%(LHV) by reducing heat loss from reformer, owing to altering its burner structure. Partial output efficiency was also improved by optimizing the operation parameters.

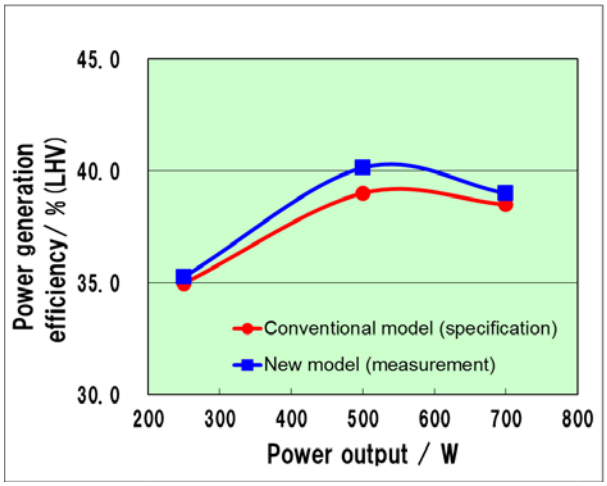

Fig.5 Power generation efficiency

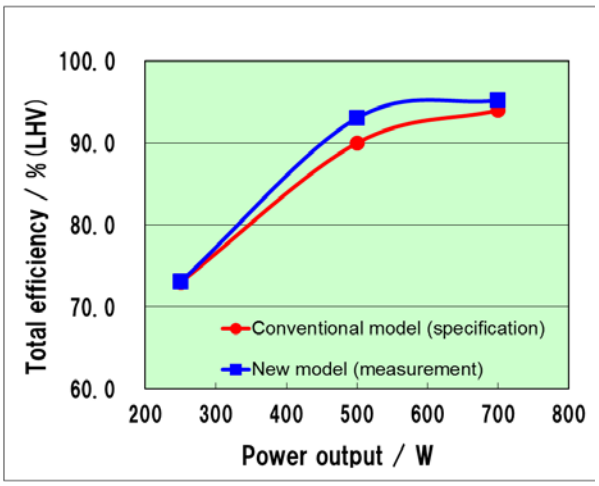

Fig.6 Total efficiency

2-3.3 Reduction of system cost

Figure.7 shows the cost reduction items of the new model. Assembling process was made more efficient and some components cost was decreased by severe competition of venders. In technical points, the cost cut was mainly achieved by reduction of cell stack material cost, structure simplification of reformer, and reduction of system components. For the conventional model, radiator was installed in hot water storage unit, in order to secure the lower temperature of returned water from the tank. At the new model, fuel processor's shutdown durability was greatly improved, and fuel cell system is designed to be shut down, in case hot water storage tank is filled with hot water. Accordingly, radiator was removed. By these items, the unit price of the new model decreased by 25% from the conventional one.

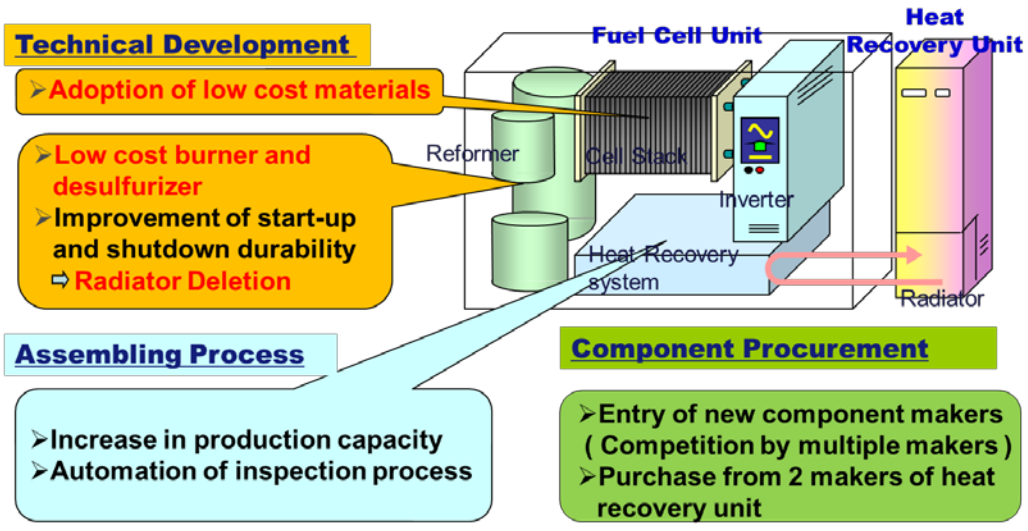

Fig.7 Contents of cost reduction of new model system

2-3.4 Reduction of installation space

ENE-FARM is designed to be placed outside the house. The distance of the wall of a house and a site boundary is short in many cases in Japan. Therefore, in order to expand the market, it is one of the most important key points that the minimizing the installation distance from the wall. Figure.8 shows the installation space of the conventional model. The conventional model is designed on the assumption of the maintenance from front side. Therefore, the distance from wall needs 790mm. For the new model, it was enables to access from the diagonal direction in case of system maintenance, owing to the optimization of components layout, and to improving system panel arrangements. Therefore, the required distance from wall for installation was reduced from 790mm to 700mm.

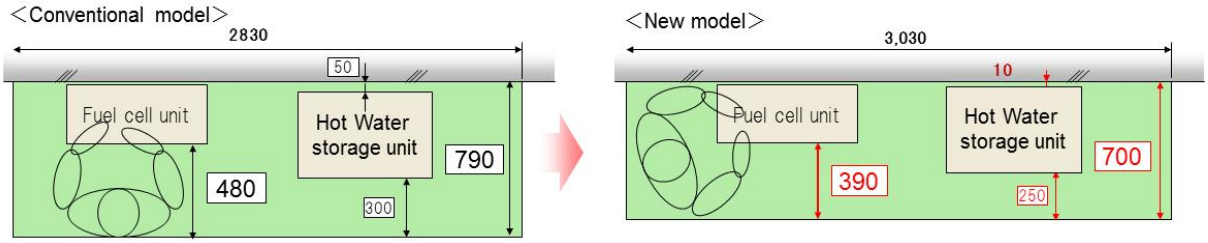

Fig.8 Reduction of installation space

2-3.5 Reduction of test run duration

The test run is conducted to confirm the system soundness, after it is installed at the customer's site. In the case of PEFC system, it requires long time because reformer needs to be heated to high temperature, and this is why installation expenses become high. Therefore it is important to shorten this time in order to cut down the installation cost. Figure.8 shows the time schedule image of the process of installation and test run. At the conventional model, the test run of fuel cell unit and hot water storage unit took three hours in total. We developed the shortened sequence of the start-up process of reformer. Furthermore, we adopted the improved process that is to accelerate the start time of test run of fuel cell unit and to reduce shut-down sequence. Thus, test run was shortened for 100 minutes at new model.

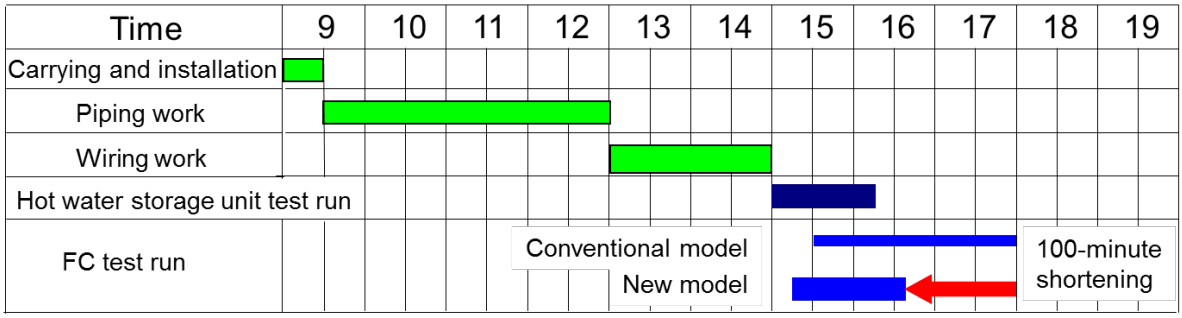

Fig.9 Time schedule image of the process of construction and test run

2-3.6 Adoption of a high functional remote controller

ENE-FARM attaches a remote controller, with which users can operate hot water supply to bath and floor heating, and browse its energy status of the house; that is power generation, electric power consumption, purchased electric power, and gas & hot water consumption.

Osaka Gas has developed the value-added remote controller in conventional model. Figure.9 shows displays of remote controller of the new model. By adopting a 4.3-inch color screen, its display became more user-friendly. Moreover, wireless LAN module was built in the remote controller. This enables operation of hot water supply to bath and floor heating from customer's smart phone by using commercial wireless LAN router. It also enables to check the energy information, including the amount of power generation etc. Figure.10 shows an example of smart phone display about the energy status.

Top　　Energy monitor

Fig.9 Displays of remote controller of the new model

Fig.10 Smart phone display about the energy status

2-4 Conclusion

Osaka Gas has continued to develop PEFC cogeneration system since 1999, and has released a new model “ENE-FARM” in April 2014.

The new model ENE-FARM has following features; significant reduction of system cost, improvement of system efficiency, reduction of installation space, reduction of test run duration, and adoption of the remote controller with a built-in wireless LAN module.

According to Japan Revitalization Strategy, Japanese government shows the target to spread 5.3 million volumes of residential fuel cell cogeneration systems by 2030. Osaka Gas continues to develop more marketable ENE-FARM, and contributes to achieve this target, and consequently contributes to customer’s comfortable life and the improvement of the global environment.

3. Reference

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