Increasing Spread of Micro CHP and Improvement of Added Value as Secure Power Supply System

Hiroaki Ishida, Shunsaku Nakai, Junichi Fujita, Kazuto Tokuda
Osaka Gas Co., Ltd.
Toshiyuki Hayashi, Kenichi Fukuda
Yanmar Energy System CO., Ltd.

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1. Introduction

Year on year, the number of the CHP(= Combined Heat and Power) system operating in the field has been increasing. Micro CHP is a collective term for the system of under 100kW power output. In Japan there are now more than 5100 units installed at a range of customer sites including welfare facilities, hospitals, restaurants, spas and hotels. In the Osaka Gas Co., Ltd. supply area where Micro CHP is marketed as “GENELITE”, there are more than 2500 unit installations. The sales figures of Micro CHP series in Osaka Gas area are shown in Figure 1 and the current lineup of it is shown in Table 1. Osaka Gas began selling the

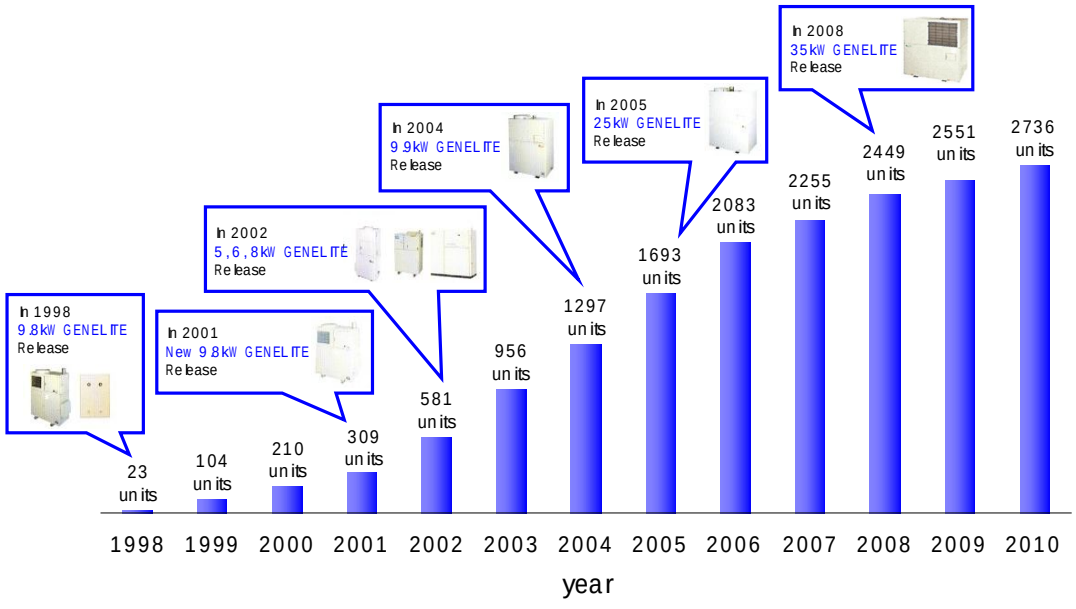

Figure1. Sales Figures of Micro CHP series in Osaka Gas Area

Table1. The Current Lineup of Micro CHP Series

Type	5kW	6kW	9.9kW	25kW	35kW
Maker	Yanmar Energy System	Aisin Seiki	Yanmar Energy System	Yanmar Energy System	Yanmar Energy System
External Appearance	 CP5VB-SNJB	 GECC60A2ND	 CP10VB1(Z)-SNB	 CP25VB3(Z)-TNB	 CP35VC(Z)-TN
Generation Efficiency	29.0%	28.8%	31.5%	33.5%	34.0%
Exhaust Heat Recovery Efficiency	56.0%	56.2%	53.5%	51.5%	51.0%
Total Efficiency	85.0%	85.0%	85.0%	85.0%	85.0%

9.8kW Micro CHP in October 1998 and has since expanded the lineup to meet the demands of diverse customers. With the aim of increasing spread of Micro CHP, Osaka Gas Co., Ltd. and Yanmar Energy Systems Co., Ltd. jointly developed the 35kW Micro CHP of high output and efficiency, which was released onto the market in November 2008. In the under 100kW class, it achieved the world's highest generating efficiency of 34%.

From experience with the Great Hanshin earthquake in 1995 and the Great East Japan earthquake in 2011, customers have placed emphasis on measures to power shortage in case of power grid failure. The standard CHP stops the operation in case of it. In contrast the black start model CHP with secure power supply system can operate in island mode even if power grid failure happens. So it is attracting attention. Even in small size customers, the use of electricity during power grid failure is recently needed. Osaka Gas Co., Ltd. and Yanmar Energy Systems Co., Ltd. jointly have designed secure power supply system with the black start CHP and have got a lineup for various needs of customers.

In this report we introduce "Development for High Efficiency of the 35 kW Micro CHP" with the aim of increasing spread of Micro CHP systems and "Improvement of Add Value as Secure Power Supply System" which make it possible to supply power even if power grid failure happens.

2. System of the 35kW Micro CHP

2-1. Specifications

The 35kW Micro CHP has a total efficiency of 85% and maintenance interval of 10,000 hours and has a power generation efficiency of 34%, which is one of the highest figures in the

world for systems with an output power of 100kW or less. For versatility, the system comes with the standard model which is connected to the power grid, and the black start model which has batteries so that island operation is possible even when the power grid fails. Figure 2 and Table 2 show the external appearance and specifications of the 35kW Micro CHP, respectively.

Figure2. The External Appearance of the 35kW Micro CHP

Table2. The Specifications of the 35kW Micro CHP

Model				CP35VC-TN (Standard Model)	CP35VCZ-TN (Black Start Model)
Generator	Rated Power		kW	35.0	
	Frequency		Hz	50/60	
Heat Recovery	Exhaust Heat Recovery		kW	52.5<51.5>	
	Hot Water Outlet Temp.		℃	80(Max88)	
Engine	Fuel Comsumption		kW	103	
Efficiency	Generation Efficiency		%	34.0	
	Exhaust Heat Recovery Efficiency		%	51.0<50.0>	
	Total Efficiency		%	85.0<84.0>	
System	Dimensions	Width	mm	2,000	
		Depth	mm	1,100	
		Height	mm	2,000	
	Weight		kg	1,470	1,530
Maintenance Interval			hr	10,000	

Figures in <> indicate the efficiency when hot water outlet temperature is 88℃

2-2. System Flow

The system consists of a gas engine, a generator, and other equipments including an inverter, and supplies electricity and hot water. Electricity produced by the generator is routed to the power grid through the inverter. Figure 3 shows the system flow of the 35kW Micro CHP system (black start model). Exhausted heat is recovered from the engine unit and used to heat water in the exhaust heat utilization unit for hot water supply or room heating.

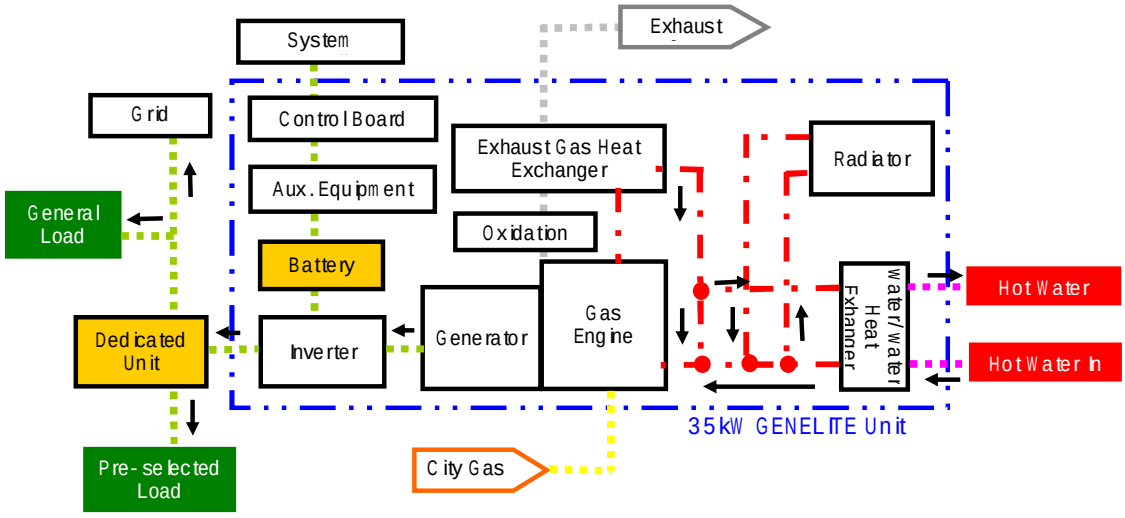

Figure3. System Flow of the 35kW Micro CHP (Black Start Model)

3. Development for High Efficiency of the 35kW Micro CHP

3-1. New Development of Gas Engine

In order to achieve high efficiency, the gas engine for the 35kW Micro CHP unit was newly developed. The engine that was developed is a single chamber lean burn engine operating with a Miller cycle. This engine design was optimized by the testing of engine and the analysis of fuel combustion with changes made to the combustion chamber design, compression ratio and valve timing, all these factors are known to influence engine efficiency. The external appearance of testing engine is shown in Figure 4. Also, the thermal efficiency of this engine was increased by optimizing the mixer configuration to allow the use an even leaner mixture and by reducing pressure losses in the engine aspiration system. The result is that in the under 100kW class, 35kW Micro CHP achieved the world's highest generating efficiency of 34%

3-2. Control of Multiple-unit Operation

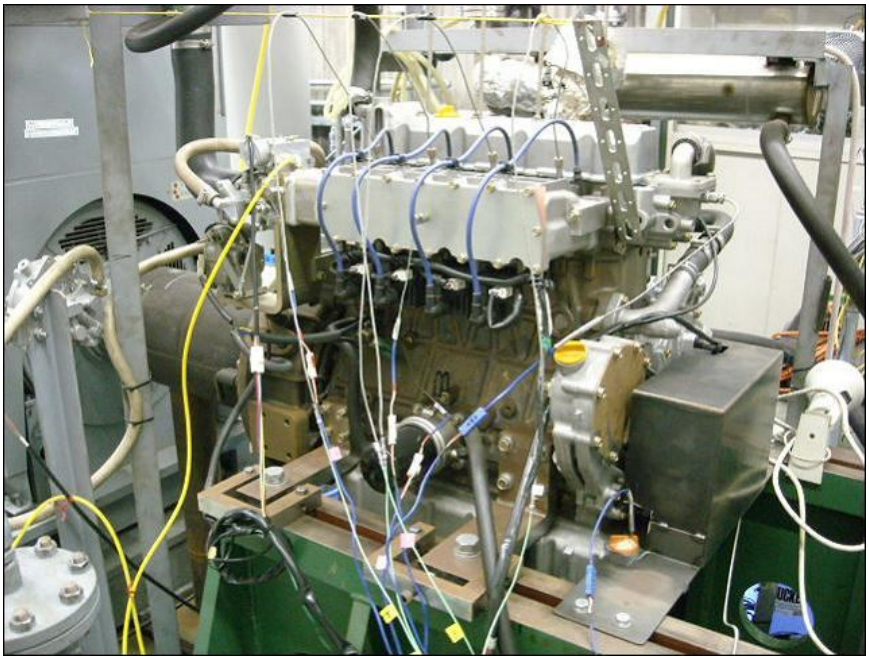

Figure4. The External Appearance of Testing Engine

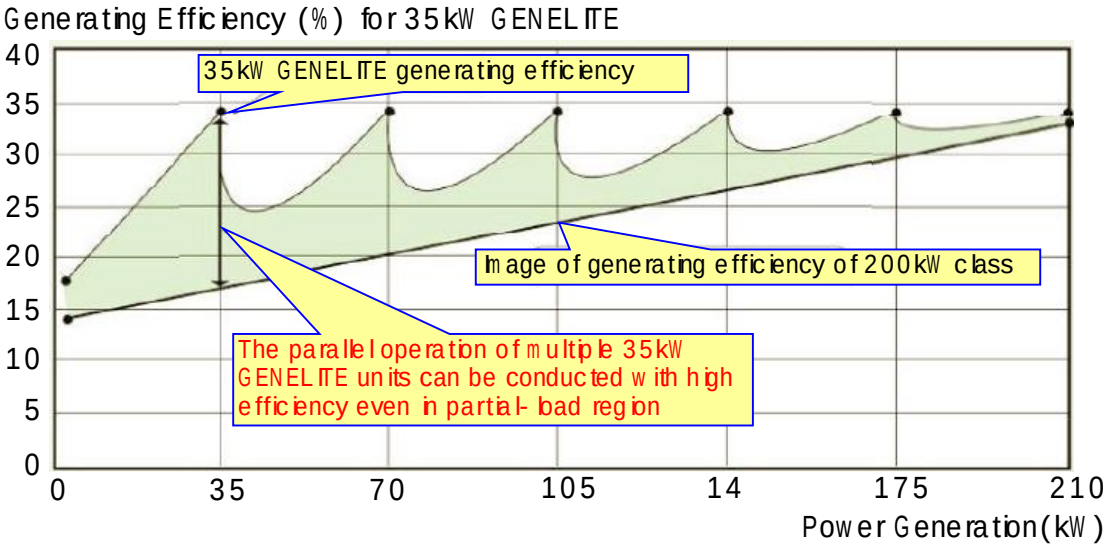

Figure5. Comparison of Generating Efficiency between Multiple-unit Operation of the 35kW Micro CHP and 200kW Class Unit

The system controller enables the use to control the operation of multiple units up to 16 units. High efficiency operation on partial load is possible by controlling the number of units in operation. Comparison of generating efficiency between multiple-unit operation of 35kW Micro CHP and 200kW class unit is shown in Figure 5. Rotation operation balances the

operating hours of each unit, this enables the maintenance costs are reduced by being able to do maintenance on all the units during the same maintenance period. The appropriate number of units for the required load operate, and units are operated on a rotation basis in order to keep the operating hours of each unit nearly equal.

4. Improvement of Add Value as Secure Power Supply System

As customers place emphasis on measures to power shortage in case of power grid failure during recent years, there is the growing needs for not only energy saving and low-CO2 but also secure power supply. Even in small size customers along with medium and large size customer, the use of electricity during power grid failure is needed. To meet their demands we have designed secure power supply system using Micro CHP. The view of secure power supply systems by Micro CHP is shown in Figure 6. In the following part we introduce them respectively.

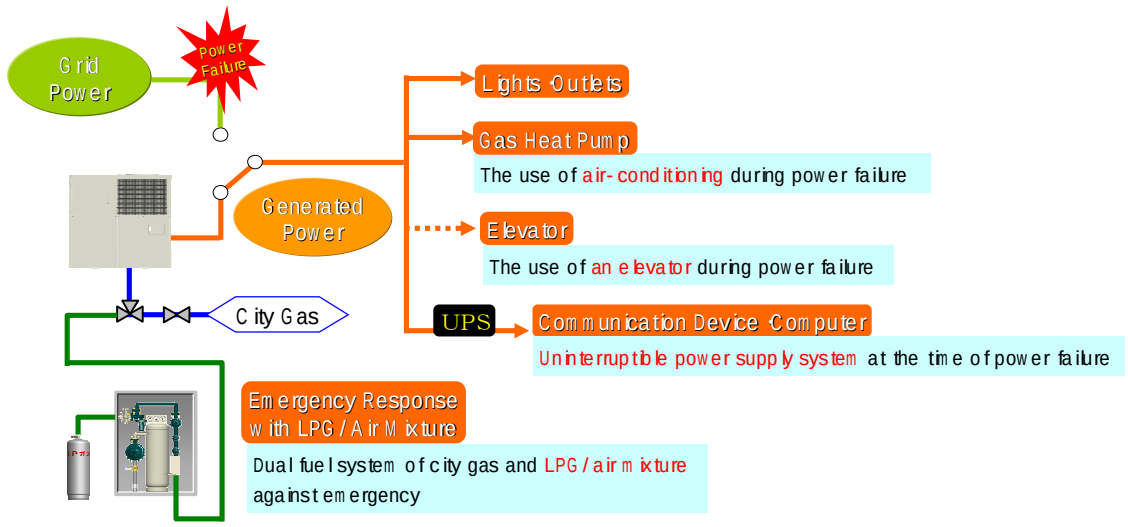

Figure6. The view of Secure Power Supply System by Micro CHP

4-1. Black Start Model

The Micro CHP over 9.9kW has a black Start Model which is possible to start up in island mode at the time of power grid failure. The black start model has a battery built in the package. The battery supplies the controller and starter with electric power to start up in island mode during power grid failure. And the black start model CHP can supply the pre-selected load (e.g. lighting and outlet) with electric power in combination with the dedicated unit (switching board).

4-2. Air-conditioning System and Elevator System Combined the Black Start Model Micro CHP

The former system enables air-conditioning to be available during power grid failure by the combination with the black start model Micro CHP and GHP (=Gas Heat Pump). The power consumption of GHP is 2% that of EHP (=Electric Heat Pump). As a result, the combination system with GHP enables lager space to be air-conditioned than that with EHP

The latter system enables the use of elevator to be available during power failure by the combination with the black start model Micro CHP and an elevator. The system is suitable for high-rise offices and condominiums.

4-3. Uninterruptible Power Supply System with UPS

We designed the system to be able to supply power to essential loads for a long time with no instantaneous power interruptions during power grid failure by connecting the 35kW Micro CHP unit (black start model) as the primary power source of a UPS (=Uninterruptible Power Supply). The system flow is shown in Figure 7. In the case of a standard system, when power grid fails and the Micro CHP system switches from the grid-connected operation mode to the island operation mode, there is a momentary interruption of electric power to loads. However, with the present system, power flow from the UPS to essential loads will be maintained even when the operation modes are being switched from one to another. Once the island operation is established, the Micro CHP supplies power to the UPS so that power can be stably supplied to essential loads even if power grid failure continues for a long time. This system is suitable for places such as data centers and Info-Communications Bureaus

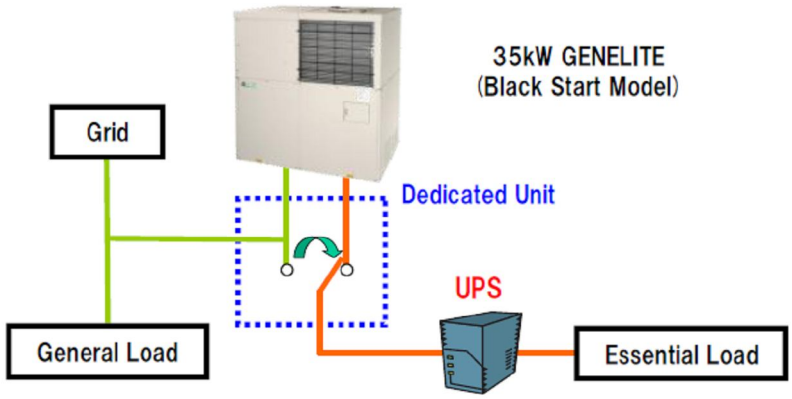

Figure7. System Flow of Uninterruptible Power Supply System with UPS

where the supply of power to essential loads must be maintained even in case of a power grid failure.

4-4. Emergency System with LPG/Air Mixture

An emergency system with an LPG (=Liquefied Petroleum Gas)/air mixing unit can supply power even if the power grid and the city gas supply network fails by natural disasters. The system includes LPG cylinders, which are relatively easy to handle and store, and an LPG/air mixing unit close to the Micro CHP unit. LPG and air are then mixed and supplied to the Micro CHP unit, which starts up in island mode and supplies electric power to essential loads. We modified the air inlet configuration of the LPG/air mixing unit to produce a higher calorie mixture, and verified that the performance in using LPG/air is almost equal to that in using city gas. Figure 8 compares the performance between city gas and the LPG/air mixture. The figure reveals that the load input and shut-down characteristics of the LPG/air model are no different from those of city gas, and that the engine rpm stays within the normal range of operation. Since the desired operating time of the system can be set by choosing the number of LPG cylinders, the system can be configured to match the customer's needs.

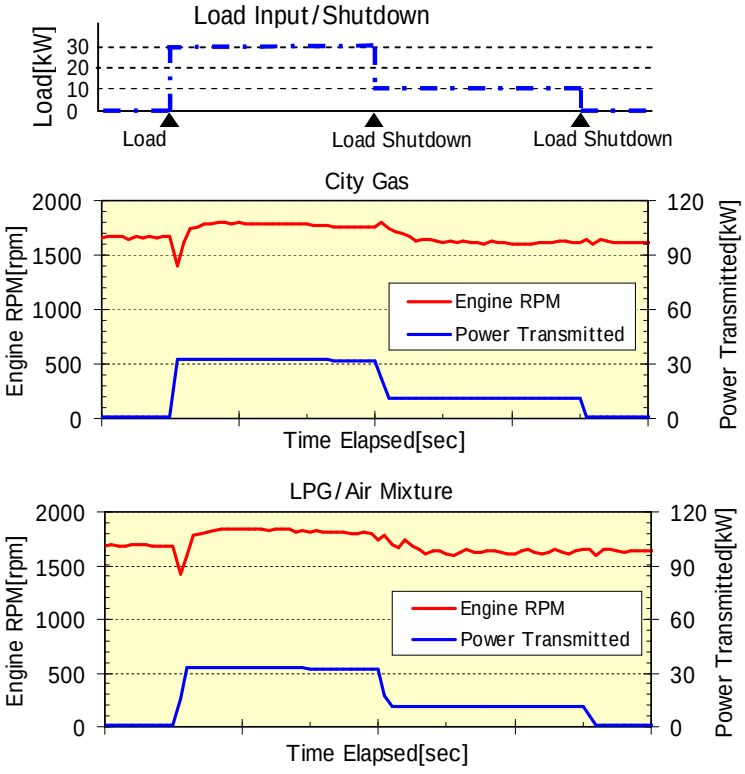

Figure8. Comparison of the Performance between City Gas and LPG/Air Mixture

4-5. Example in the Hikone Gas Building, Osaka Gas

The secure power supply system of Micro CHP, which was installed and has been operating in our Hikone Gas Building since January 2011, is as follows. In addition to the well-established, energy-efficient, low-cost, and low-CO2 emission characteristics of Micro CHP systems to date, this latest system has the following characteristics: (1) It comes with seven

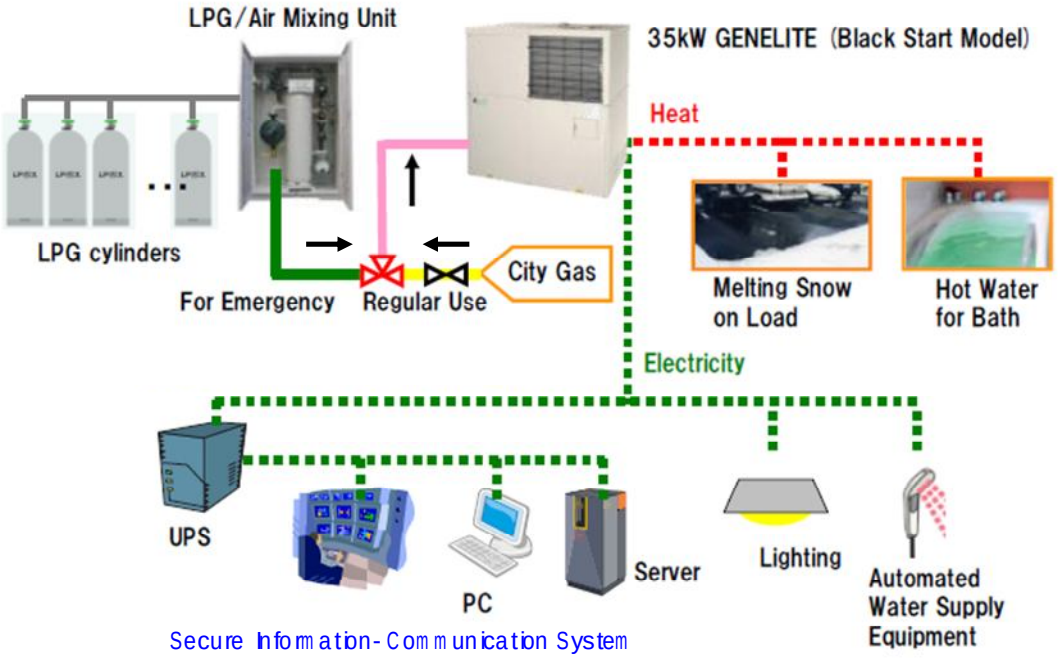

Figure9. System Flow in the Hikone Gas Building

Figure10. The External View of the Hikone Gas Building

LPG cylinders (each containing 50 kg of LPG) so that in emergency, the Micro CHP unit is driven by an LPG/air mixture, thus supplying power to essential loads for 24 hours. (2) An UPS has been incorporated so that even if the power grid fails, the system can continue to supply power to essential loads with no instantaneous power interruption. Figure 9 shows the system flow in the Hikone Gas Building, and Figure 10 shows an external view of the Hikone Gas Building. Now that the building has the Micro CHP system with a UPS and LPG/air mixing unit, and so can continue to supply power to essential loads at the time of a blackout and when the city gas network is disrupted, the building is expected to play an important role as a disaster control center if necessary.

4-6. Approach From Now

As the approach from now, we will expand the lineup of the Micro CHP in terms of high power output and efficiency. In addition, to improve the added value we will develop the low cost gas mixture system of biogas and city gas.

5. Conclusion

Micro CHP is a highly efficient and which realizes energy-saving and low-CO2. Additionally, to improve secure power supply system using Micro CHP we developed the system which makes it possible to use air-conditioning or elevator, the system which supplies uninterruptible power by a connection to a UPS and the system which generates power by LPG/air mixture as the backup of city gas. As a result of these, we have a multiple of secure power supply system. And in the future, we will expand the range of application continuously.

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