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SPREAD OF GHP AND FUTURE DEVELOPMENT

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ABSTRACT

A Gas Heat Pump air conditioner (GHP) is the air-conditioning system that drives the compressor equipped in the outdoor unit with the gas engine. The number of GHP installed is growing every year due to increased awareness of their advantages such as energy efficiency, small power consumption and low running cost.

In Japan, more than 20 years passes since GHP was released in 1987. We steadily carried out the development of high efficiency GHP, improvement of the reliability, reduction in cost and the expansion of the product variety. As a result, there is the sale number of GHP in a tendency to increase steadily and establishes a firm position in an air conditioner for commercial use by the present.

Recently, the nuclear power plant is damaged by East Japan great earthquake disaster, and electricity shortage of the summer is concerned about, and there is the area pressed for 15% of economy in power consumption recently in Japan. GHP which is electric power saving attracts attention more and more very much in Japan.

The hybrid power generating system using renewable energy which fused by GHP with the power generating function and the photovoltaic power generation was commercialized in April 2011.

In this paper, we introduce the spread of GHP and the latest trend.

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2.1. Introduction

A Gas Heat Pump air conditioner (GHP) is the air-conditioning system that drives the compressor equipped in the outdoor unit with the gas engine. The number of GHP installed is growing every year due to increased awareness of their advantages such as energy efficiency, small power consumption and low running cost.

In Japan, more than 20 years passes since GHP was released in 1987. We steadily carried out the development of high efficiency GHP, improvement of the reliability, reduction in cost and the expansion of the product variety. As a result, there is the sale number of GHP in a tendency to increase steadily and establishes a firm position in an air conditioner for commercial use by the present.

2.2. Advantages and the spread of GHP

The accumulated sales capacity of GHP in Japan from FY1995 to FY2009 becomes 20.4 million kW (104% compared with the previous fiscal year) as shown in Figure1. The sales volume in Japan is about 211,000 units from FY2003 to FY2009 whereas the volume of it in other regions in the world is about 32,000 units as shown in Figure2. The volume of sales in Japan is about 6.5 times of it in other regions in the world.

This depends on the next reason.

a. In the summer, an air-conditioner is used in Japan because of its hot and high humidity. Power peak appears in daytime of summer to use the air conditioner. That is why Power peak cut by GHP is socially necessary.

b. The gas consumption of the summer is smaller in Japan than the winter, and it is necessary for the gas company to let gas consumption of the summer increase from the viewpoint of utilization of a gas storage and supply facilities. Therefore the gas company handles GHP as a strategic product, and we build the system to sell the GHP.

Furthermore, to enlarge a GHP market, it will be necessary in future that the improvement of the efficiency and the correspondence to the huge variety of customer needs.

2.3. The latest trend

The performance and the reliability of GHP improved drastically in these 20 years, and the product variety has been expanded, too. Furthermore, we have developed the GHP that uses the

advantage of the gas engine to the maximum.

2.3.1 Upsizing

As for the lineup of GHP, the maximum ability was 56kW since release for a while. However, upsizing of GHP is recently required for the large-scale buildings. GHP manufacturers commercialize a large-capacity GHP of 71kW or 85kW. As a result, its economical competition for the large-scale buildings improves and the variation of its cooling capacity spreads.

As another tendency of upsizing the outdoor unit, there is combination multi-type. This connects two outdoor units of 45kW-85kW and offers large capacity of 90kW-170kW. The reliability of this system improves because it can run backup with another outdoor unit even if one outdoor unit breaks down. Furthermore, the efficiency of the system improves because air conditioning load is in a small state and can run it with one outdoor unit. In addition, the extension of life of the system is realized by a rotation function to operate from an outdoor unit of little one of accumulated driving time so that driving time every outdoor unit is made a measuring level.

2.3.2 Improvement of efficiency

Development of high efficiency GHP becomes the important problem from the viewpoint of energy saving and low CO2 emission. This development has been steadily advanced since about 1998. They are especially important for development of high efficiency GHP that the thermal efficiency improvement of the engine and the improvement of the refrigeration cycle. As for the performance of GHP, it improves marvelously due to the development from these two directions and a great energy saving of about 50% is attempted compared with at first of the sale as shown in Figure3.

The performance of GHP has been evaluated up to now in COPp (Coefficient Of Performance [Primary Energy Base]) at the rated point. However, GHP is hardly driven in rated point actually, and most is driven by the partial load. Recently, the evaluation of performance under the condition near an actual usage has come to be attached to importance with the rise of the concern to the energy conservation. APF (Annual Performance Factor) was provided for as a performance evaluation index considered the partial load driving in JIS (Industrial Standards of Japan) in 2006. To evaluate the performance of GHP and EHP by the same standard, it is necessary to convert the amount of all energy consumption including power consumption into primary energy. APF converted into primary energy is shown APFp. In Rationalization in Energy Use Law in Japan, it is provided to the conversion of the electric power of 1kW into primary energy 9760kJ. The model that improves APF has been commercialized by GHP manufacturers in Japan.

2.3.3 Multifunction

2.3.3.1 GHP with power generating function

The power consumption of the conventional GHP is very small with about 1/10 of that by an electric heat pump air conditioner (EHP) of the same capacity. This feature was evolved further, GHP with power generating function was commercialized in 2003. This system generates 1 kW of electric power using the excess capacity of the gas engine during cooling and heating operations, and this power is supplied to the cooling fan motor and cooling pump, reducing the external power consumed by the outdoor unit. In the case of 56kW type, the electric power consumed by this GHP air conditioning system is just 1/150 of that by EHP of the same capacity.

Furthermore, we commercialized the GHP equipped with 4kW generator as shown in Figure4 in 2006. This system supplies generated power out of an outdoor unit through a grid interconnection. Electric power is generated using the excess power of the gas engine during cooling and heating operations. As a result, the generating efficiency* during the rated cooling/heating operation is about 45% (in terms of low calorific value (LHV)), and during partially loaded operation is about 45–55% (LHV), surpassing the average demand-end generation efficiency of domestic fossil-fired power stations, which is approximately 40%.

* The power-generating efficiency of a generator installed in an outdoor unit is obtained by the following equation (1):

$$\text{Generating efficiency} = \frac{\text{Generated output (kW)}}{\text{Gas consumption increased by power generation (kW)}} \qquad (1)$$

GHP with power generating function can supplement the reduction even a little because the amount of the gas sales increases by power generation though it tends to decrease by making GHP in recent years highly effective.

2.3.3.2 Simultaneously cooling and heating

The cooling load might exist together to the heating load in space with different use conditions. In such a condition, GHP that operates cooling and heating at the same time by one outdoor unit has been commercialized. This system is shown in Figure5. Under the simultaneously cooling and heating conditions, the performance of this system is very high because the waste heat of the indoor unit in cooling operation and the engine waste heat are effectively used as a heat source of the heating operation.

2.3.3.3 Supplying hot water

GHP with the function of hot water supply improves total efficiency of GHP because it can effectively use the engine waste heat of it. This function is evaluated in Europe by the overseas presence of GHP, and this function has been almost added to GHP for Europe.

2.3.4 Remote supervisory control system

The remote supervisory control system provides the service that observes operating condition of GHP for 24 hours. Because we learn the detailed information before receiving the call from the user because breakdown information is automatically sent to the control center even if GHP breaks down by any chance, this system enables the failure detection at the early stage and repair in a short time.

Service in which the user can monitor the condition of GHP and the gas consumption on the Internet has been put to practical use as additional service as shown in Figure6. Moreover, we are providing service to which the operating start/stop and the temperature management of the GHP indoor unit are automatically done by remote control while observing a useless operation such as forgetting to stop the GHP indoor unit and an excessive temperature setting. This service supports the user's energy conservation operation throughout the year.

2.3.5 The hybrid power generating system using renewable energy

The photovoltaic power generation is very clean energy. However, as for the quantity of generation, the quantity of generation fluctuates by weather and time to change by quantity of sunlight. On the other hand, as for GHP with power generating function equipped with 4kW generator, the generation output fluctuates by air conditioning load to control quantity of generation by the surplus power of the gas engine as shown in Figure7.

In addition, this system cannot generate electricity during the period not to operate air conditioning because this system realizes high efficiency generation by generating electricity at the time of air conditioning driving. In this way, the generation output is not stable when I install the facilities that the generation output fluctuates by a setting condition and operating conditions individually. The generation output often becomes small for the inverter rating output. Therefore the system which fused in photovoltaic power generation and GHP with power generating function equipped with 4kW generator was developed as shown in Figure8. In this system, a rate of operation of the inverter improves by using inverter in common and enables stable generation by controlling quantity of generation generally. This system as shown in Figure9 was released in April, 2011.

This system uses the photovoltaic power generation output with precedence. This system controls quantity of generation to add generation by this GHP with quantity of generation to be short for the inverter rating output. This system enables the reduction of the energy consumption by using more than 40% of high efficiency generation of GHP together with photovoltaic power generation.

This GHP gives priority to air conditioning performance and runs and generates electricity in the

range of engine surplus energy. Therefore this system may not generate electricity to inverter rating when generation from photovoltaic power generation decreases. Therefore this system comprises the generation priority function that becomes able to add to engine surplus power by regulating air conditioning ability to stabilize peak power reduction more.

This system combines a natural energy with high efficiency gas generation and is the product which can contribute to electricity load equalization by stabilizing the generation output.

2.4. Future development

Recently, customer needs of energy saving and environmental improvement have risen. Therefore development of high efficiency GHP required. It is important to maintain a highly effective operation to improve APFp in the area where the air conditioning load is small.

We plan to develop the expansion of the engine rotation speed range and the optimization of the compressor capacity and its control technology. We will commercialize ultrahigh efficiency GHP that APFp achieves 2.05 in the maximum in April of 2011.

APFp of GHP greatly exceeds top runner standard value APFp 1.70 in 2015 of EHP if compared by 45kW type as shown in Figure10. As a result, this product reduces primary energy use and CO2 emission by approximately 20% in 45kW type compared with conventional GHP.

In addition, the hybrid generation system which fused in photovoltaic power generation and GHP with power generating function equipped with 4kW generator was developed in April 2011 as the challenge to the construction of the low-carbon society. This system is that power generation by GHP with 4kW generator supports the natural energy that is easy to fluctuate by a climate, and the stable generation output is provided. That is why this system makes it possible to reduce peak power effectively.

Recently, the nuclear power plant is damaged by East Japan great earthquake disaster, and electricity shortage of the summer is concerned about, and there is the area pressed for 15% of economy in power consumption recently in Japan. GHP which is electric power saving attracts attention more and more very much in Japan.

We will work in the development of the GHP that may be able to use the waste heat effectively and the improvement of more highly efficient GHP in the near future.

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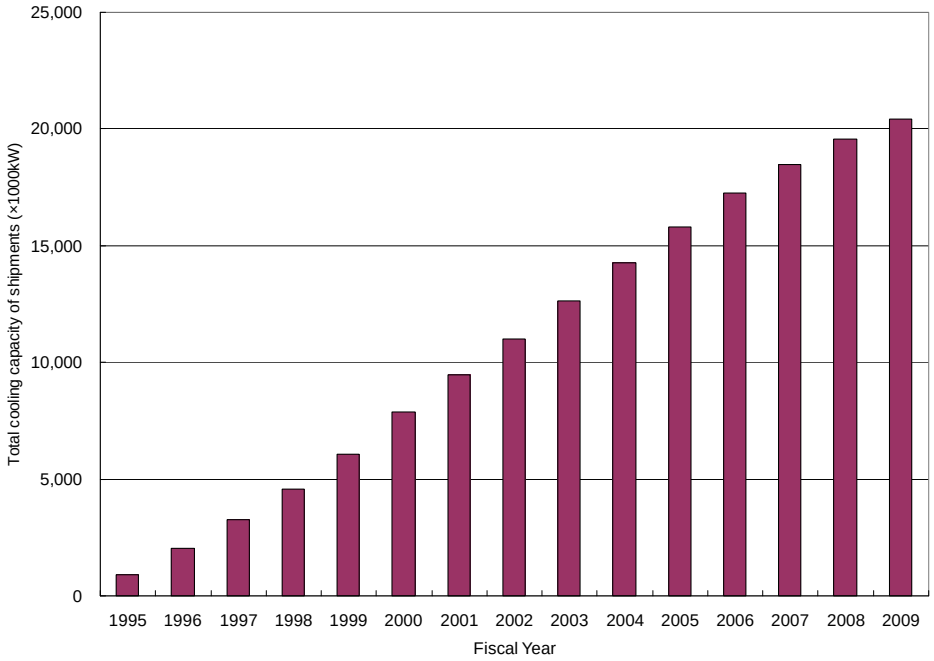

Figure1. Spread of GHP in Japan (FY1995-FY2009)

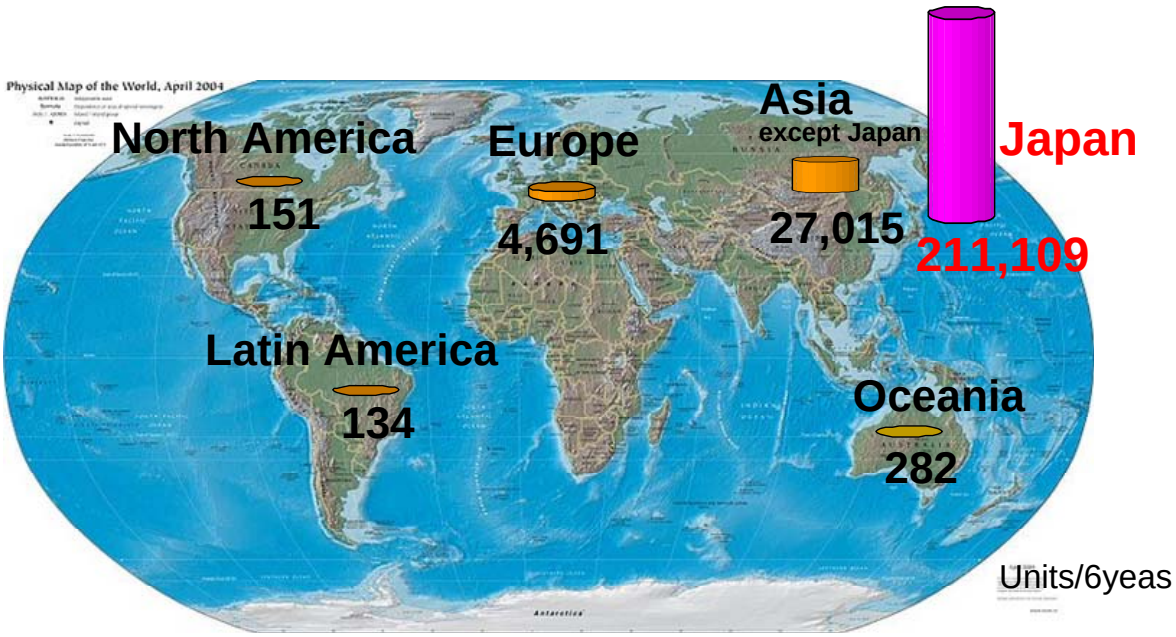

Figure2. Spread of GHP in the world (FY2003-FY2009)

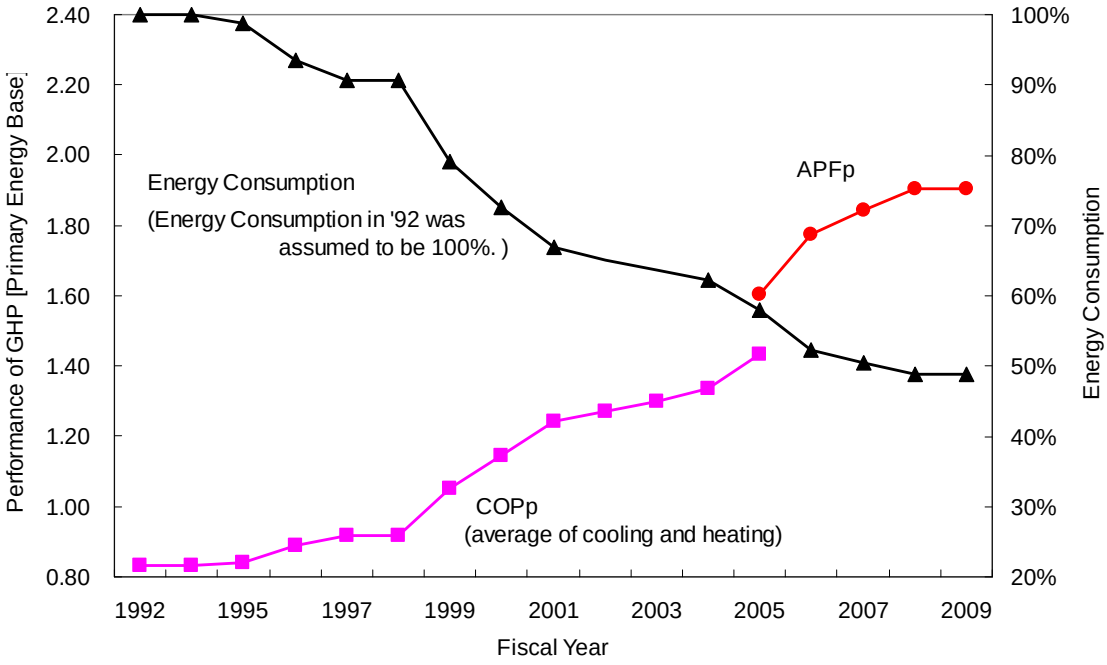

Figure3. Progress of the performance of GHP [Primary Energy Base]

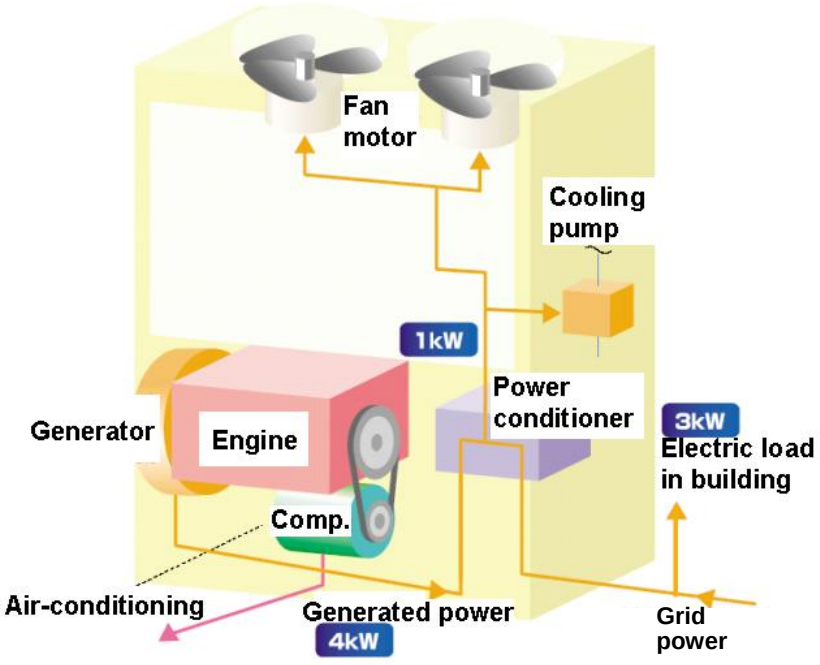

Figure4. System Outline of GHP equipped with 4kW generator

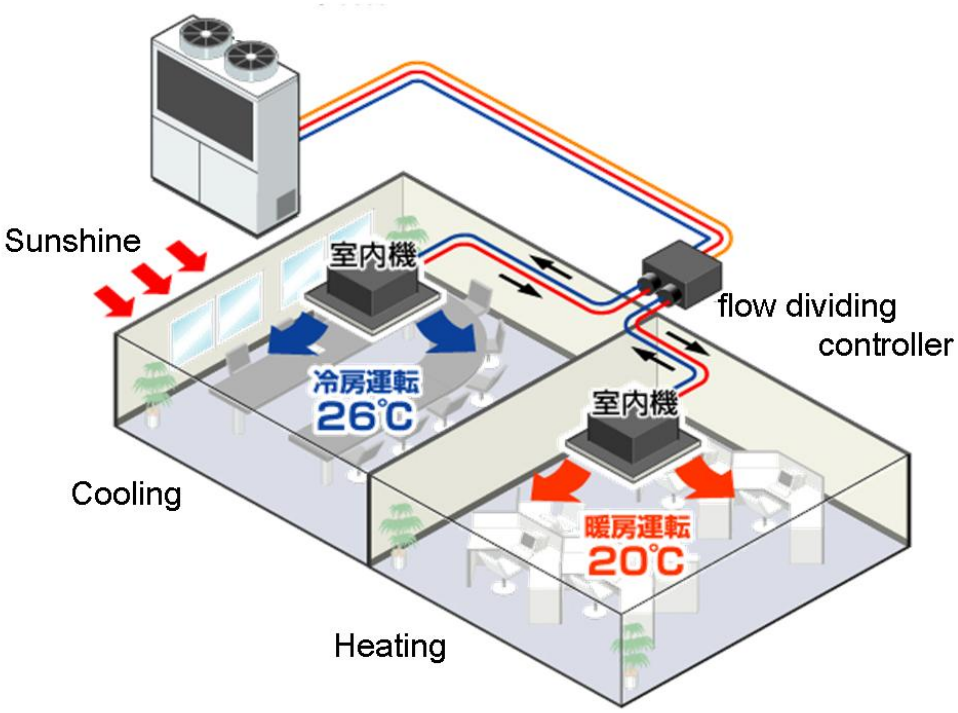

Figure5. **Simultaneously cooling and heating system**

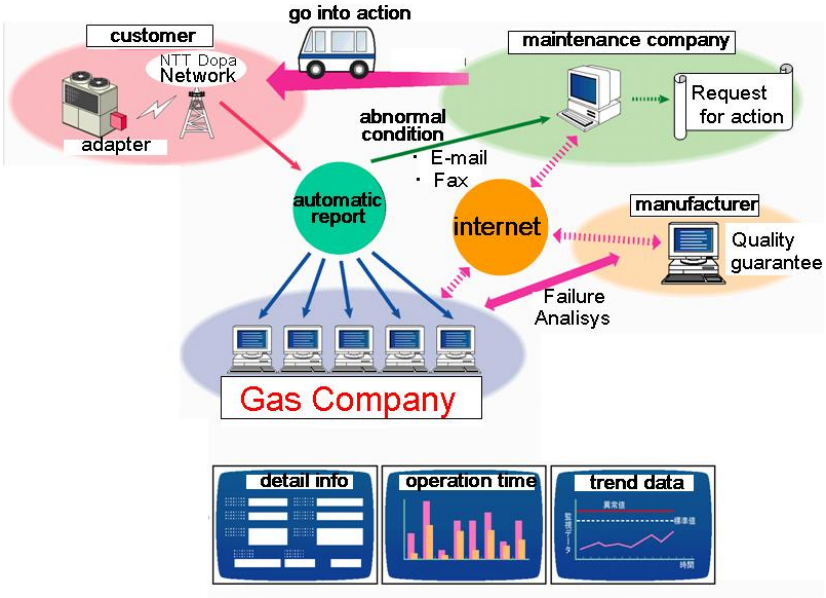

Figure6. **Remote supervisory control system**

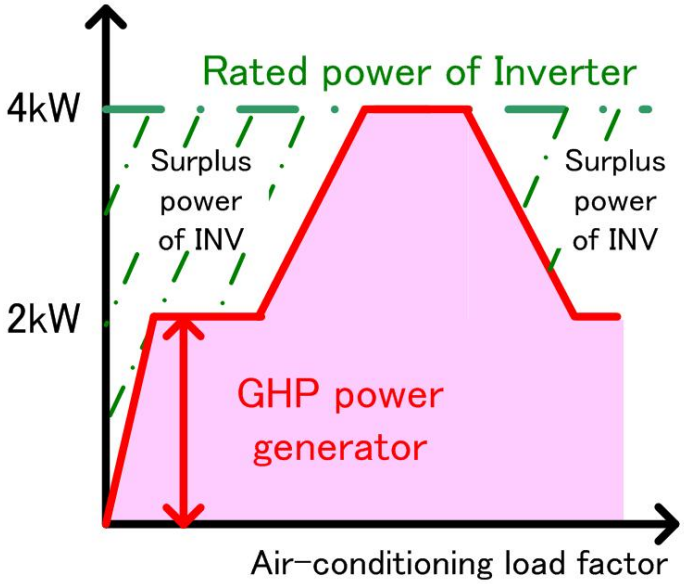

Figure7. Relations of air-conditioning load factor and
the generation output of GHP equipped with 4kW generator

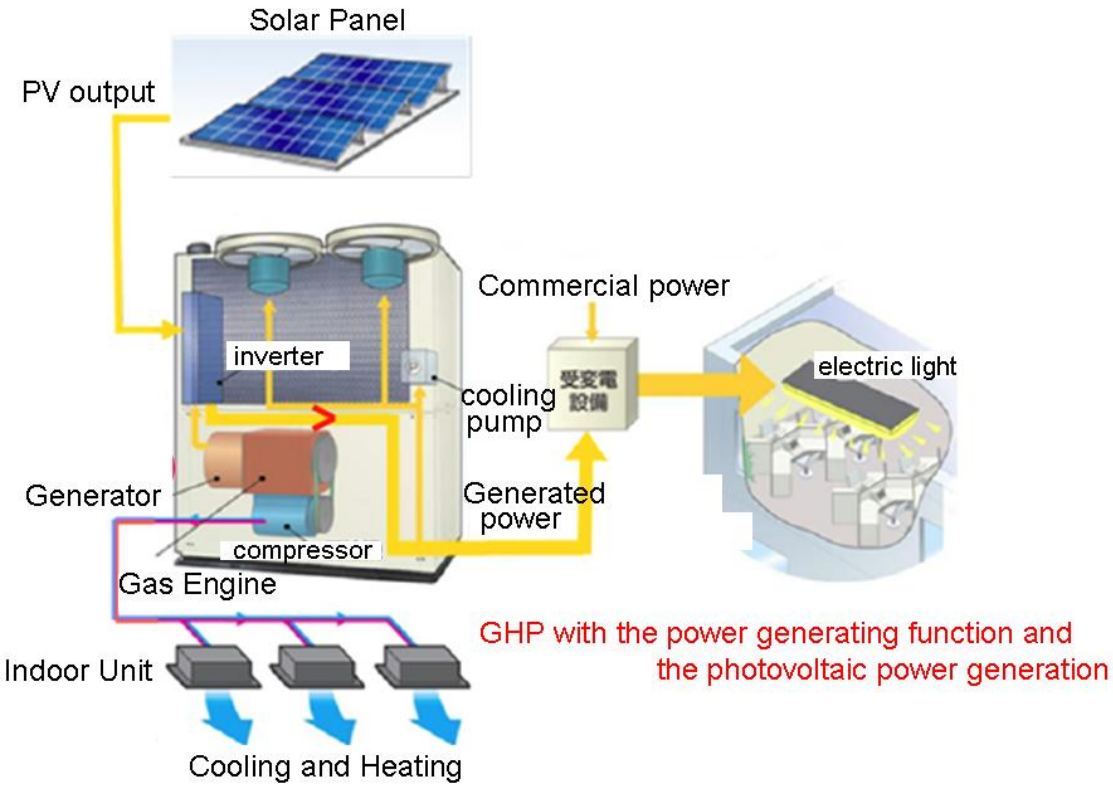

Figure8. Overview of the hybrid power generating system using renewable energy

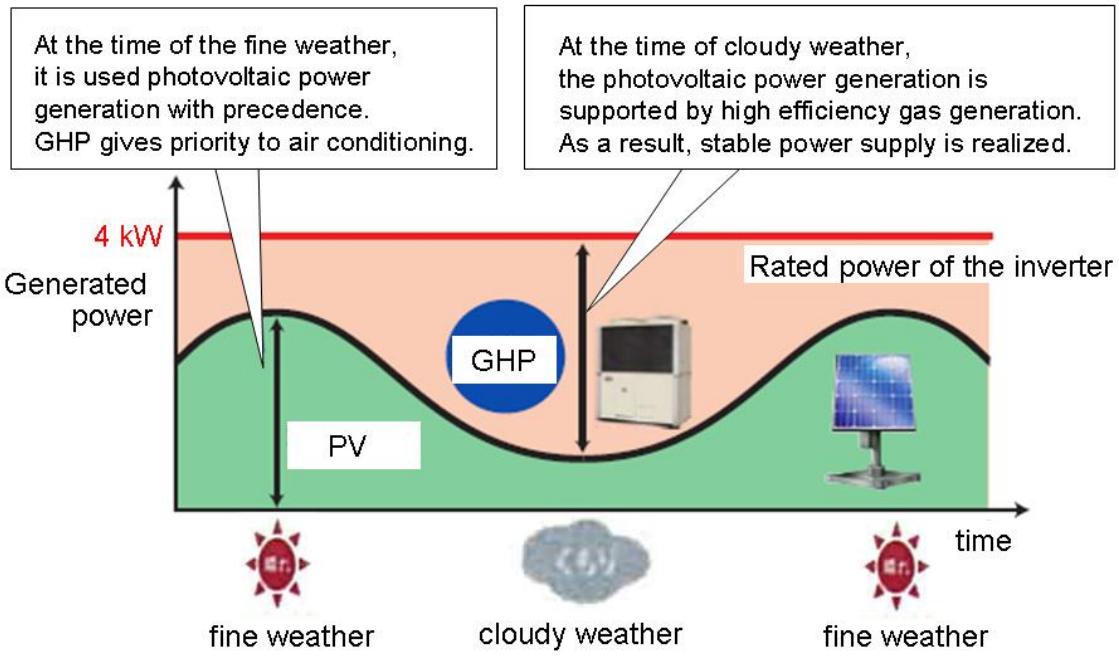

Figure9. The power generation image of the hybrid power generating system using renewable energy

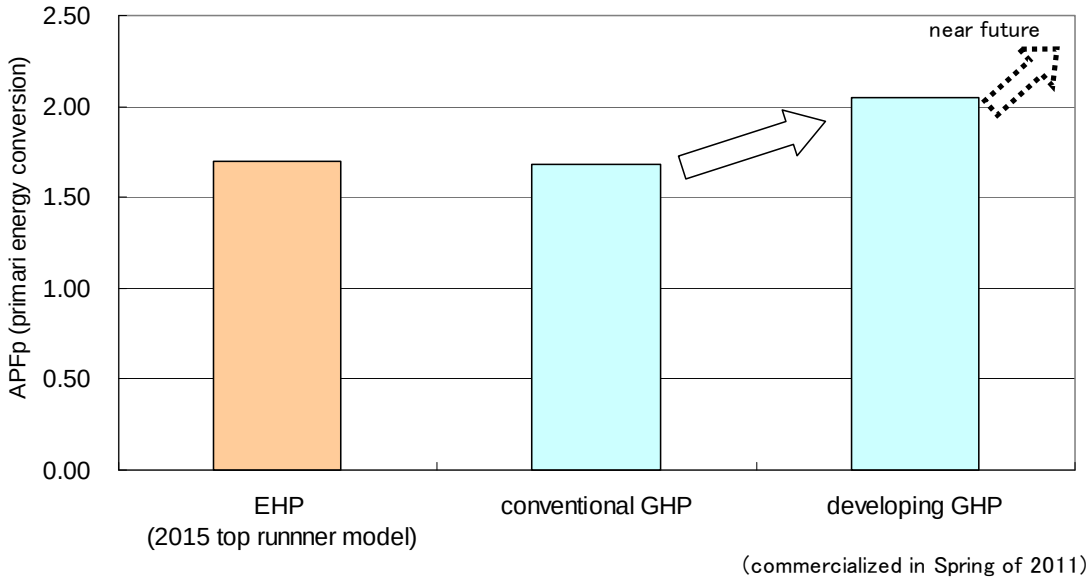

Figure10. Comparison of APFp (45kW type)