

## **Technology and Market Trend of GHP in Japan**

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### **Abstract**

The energy consumption, especially the electricity consumption, of the commercial sector in Japan is increasing recently. Air conditioning system using GHP (Gas fired engine Heat Pump air conditioner) which can promote energy efficiency and reduce the electricity consumption, especially the peak load in the summer, is getting more widely used and can be of a help to preserve the global environment.

It is mainly due to the advantages below;

- The development of GHP is corresponding to the energy policy in Japan.
- GHP is matching to the market needs. i.e. the reduced initial and operation cost.
- GHP is “easy to use and install.”

In this paper we show the trend of the air conditioning system market and the situation of the latest GHP technology development.

### **Today's over-all economic situation and air-conditioning market in Japan**

#### **1.Economy and air-conditioning market in Japan**

Japan's economic is in the state of stagnation. GDP continues to diminish and unemployment rate continues to rise in spite of various measures taken by the government.

Japan is now in the state of deflation. Industries, including construction sector and retail sector continues to vie for lower price by cutting cost and making arduous efforts to keep and win new clients. Unfortunately, the situation is not expected to reverse its course in the near future. In facing this situation, many manufacturers are relocating their productions overseas to cut production cost. As a result of this production relocation, jobs are lost in Japan and so-called “Void-Phenomenon” can be seen.

Construction industry is especially hit hard by this economic situation. Therefore it is obvious that air-conditioner manufactures are suffering as well. There is already enough office space to meet the need. Investment companies are taking no chances in building new commercial complexes under these situations.

In spite of the situation above, there are increasing needs for existing structures' renovation work. Construction industry and air-conditioning appliances manufactures have high and only hope for these renovation work and allocating their resources in sales and technology development in this market.

## 2. Energy in Japan

Under the situation mentioned above, government has taken several measures to bring down the price of electricity and gas, which is said to be relatively expensive compared to that of overseas, to stimulate the economy and revitalize industries.

One of the concrete actions taken by the government is to alleviate regulations regarding energy, including electricity and gas. Introducing free market system to formerly regulated energy market is expected to reduce the price. Other is to promote load leveling of electricity and to reduce cost for electricity generation.

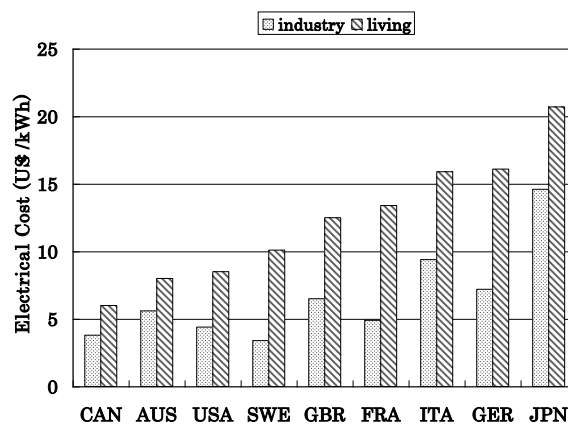


Figure 1 Electricity cost international comparison

On the contrary, life style of Japan is beginning to show resemblance to that of the US and EU. Average household now installs two sets of air-conditioning appliances and more than one motor vehicle.

Energy saving is the heart of Japan's energy policy because we depend most of the primary energy to foreign countries.

For this reason, production efficiency is high and various technologies to use energy are considered advanced. On the other hand, energy saving in commercial sector is dragging it feet. Measures to enhance energy saving in this sector are not working as expected.

Consumption of energy in the type of electricity is growing conspicuously and the need for new generator is imminent. Summer in Japan, as many of you are aware, is very hot and humid. Electricity needed for air-conditioning is high. To meet this short period but large peak demand of electricity, securing generation capacity to meet this magnitude will result to higher stranded cost for power generation.

It is important to level the load of electricity demand. Use of GHP and Gas-fired Absorption Chiller Heater, which do not use electricity as their main source of energy will help level the yearly electricity demand and will contribute to electricity peak-cutting. (Thermal Storage System will also contributes to this matter)

Energy cost reduction efforts mentioned above will lead to lower energy consumption and environment protection (cutting CO<sub>2</sub> emission). This will help meet the emission reduction target set by COP3. This is in accordance with the basic policy of Japan which fully depend on foreign energy.

Following figures will help you understand the further.

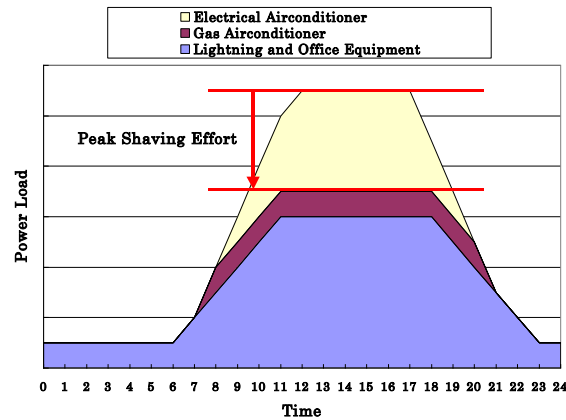


Figure 2 Electric power peak cutting of GHP

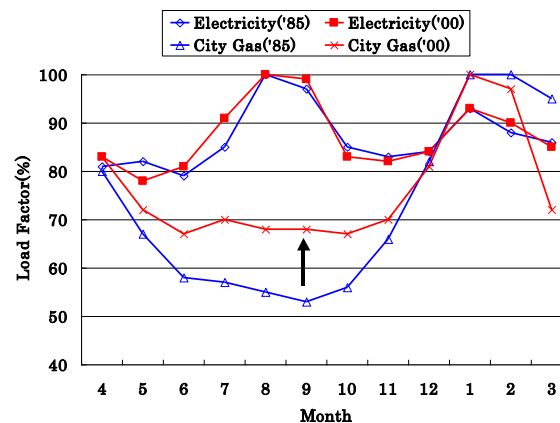


Figure 3 It is a supply situation during the year of the electric power and the gas of every month

### 3.Global environment preservation

We must not oversee the environmental preservation side in accordance with the energy saving. Through energy conservation, it is important to reduce Nitrogen-Oxide, and Sulfur-Oxide emission along with pursuing CO<sub>2</sub> emission reduction that stops the global warming.

In addition to reducing these gases, we must also pay attention to ozone destruction issue accompanying with the discharge of HCFC. Switching to HFC will help avoid the destruction of ozone layers.

Japan is pursuing the development and promulgation of air-conditioner that meet this situation. We now would like to make a brief presentation of the progress in Japan.

System development processes must take into account the variety of market needs, existing policy, easy-to-operate (convenience, easy-installation etc.).

What is required for air-conditioning appliances in Japan's market

"Compliance to policy"

- Energy saving design
- Environment preservation (Stop the global warming: CO<sub>2</sub> emission reduction, Avoidance the destruction of ozone layers)
- Contribution to electricity load leveling

"Market needs"

- Low price and reasonable operating cost
- Attractive design
- Easy to operate
- Easy to install (small & light weight)

## General aspect of GHP

### 1. Air-conditioning equipment sales

Air-conditioning system, especially GHP, is constantly increasing its capacity. Figure 4 illustrates that advantage of GHP system is well perceived by the air-conditioning market. This can also be seen in Figure 5.

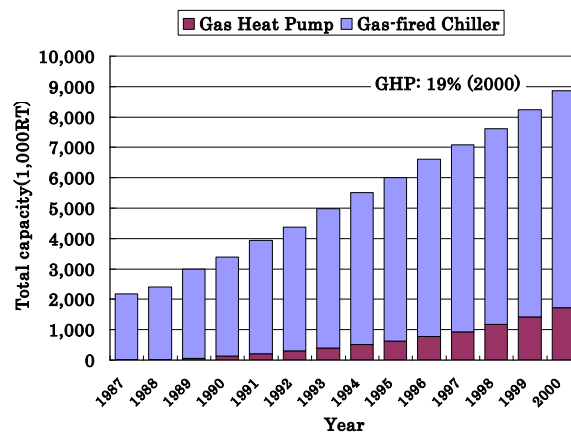


Figure 4 Accumulated installation capacity of air-conditioning system by city gas

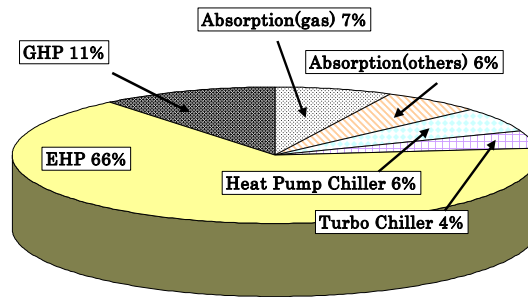


Figure 5 Market sales share of air-conditioning system

Energy saving is done by replacing fully the central air-conditioning system to local air-conditioning system in small to mid size buildings. Central systems like turbo refrigerator, heat pump chiller and gas-fired absorption chiller heater are losing their share. Local system dominates 77% of the market. (Figure 5)

As shown in Figure 6, gas-fired absorption chiller also uses city gas as its energy source. This system has more than 60% share in large building air-conditioning market. But as for the residential air-conditioning, smaller appliances are needed. Absorption type air-conditioner cannot compete with EHP (household air-conditioner) in price and easiness of installation.

Electricity demand increased, as a result of the installation of EHP system and further deteriorated the electricity's yearly demand. With the advent of GHP system, air-conditioning by city gas for small building became possible. This has contributed in cutting electricity peak and load leveling.

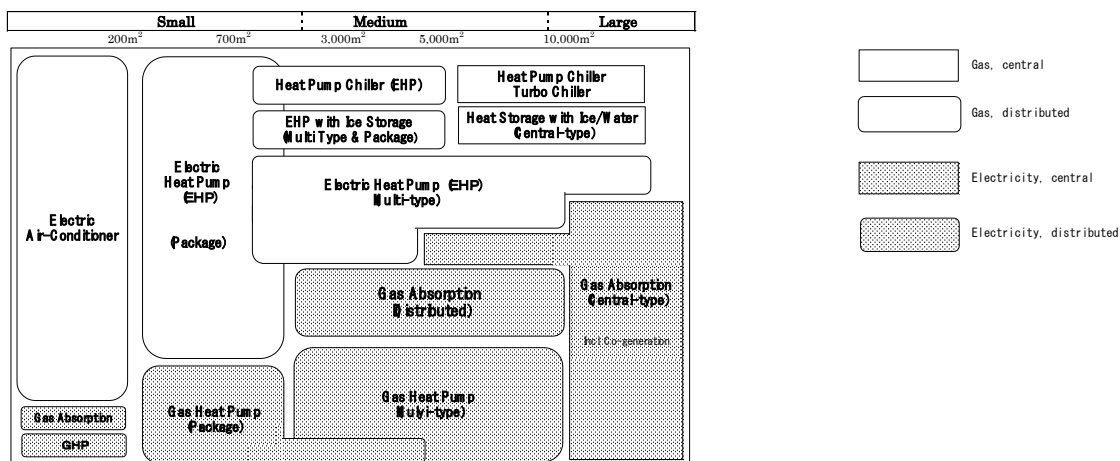


Figure 6 Share of each scale of air-conditioning system (electric power and gas)

## 2.How GHP works

As shown in Figure 7, GHP uses gas-fired engine instead of electric motor. Other than using gas-fired engine, basics of operation are same with EHP. In Japan, usually both cooling and heating are taken care by single system. Therefore, most of air-conditioning appliances hold 4-way valve to make a switch between cooling and heating. Advantages of GHP are as follows;

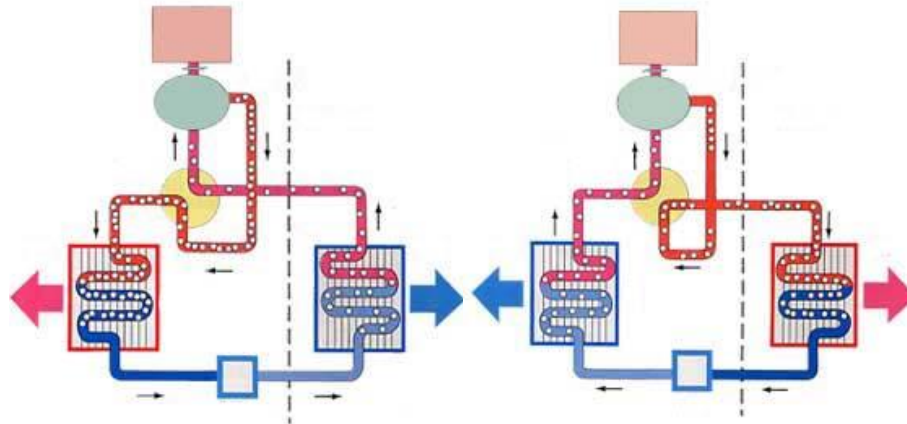


Figure 7 Outline of principle

## 3.Feature of GHP (advantages)

- **Need small electrical power, 1/10 of EHP.**

Since GHP uses gas-fired engine as its driving force, it uses very little electrical power. Clients can cut the cost of electricity receiving equipment and basic contact fee with the utility. This will contribute to electricity load leveling.

- **GHP is especially superior to EHP in heating mode**

GHP can recover and utilize heat emitted from gas engine (COP for heating is over 1.5). GHP can be used in colder weather areas. Heating start-up time is short. GHP needs no deforestation mode operation and out-put capacity will not be affected by the temperature.

- **Low running cost**

GHP is relatively expensive compare to EHP. But taking into account the advantage of operating cost, difference of acquiring cost can be recovered in 3 to 5 years. Therefore it is economically advantageous compare to EHP.

- **GHP's COP is equivalent to that of EHP (primary energy comparison)**

GHP's COP is equivalent or superior to that of EHP in general. GHP's latest model has high performance (average cooling COP is over 1.3) and is superior to EHP.

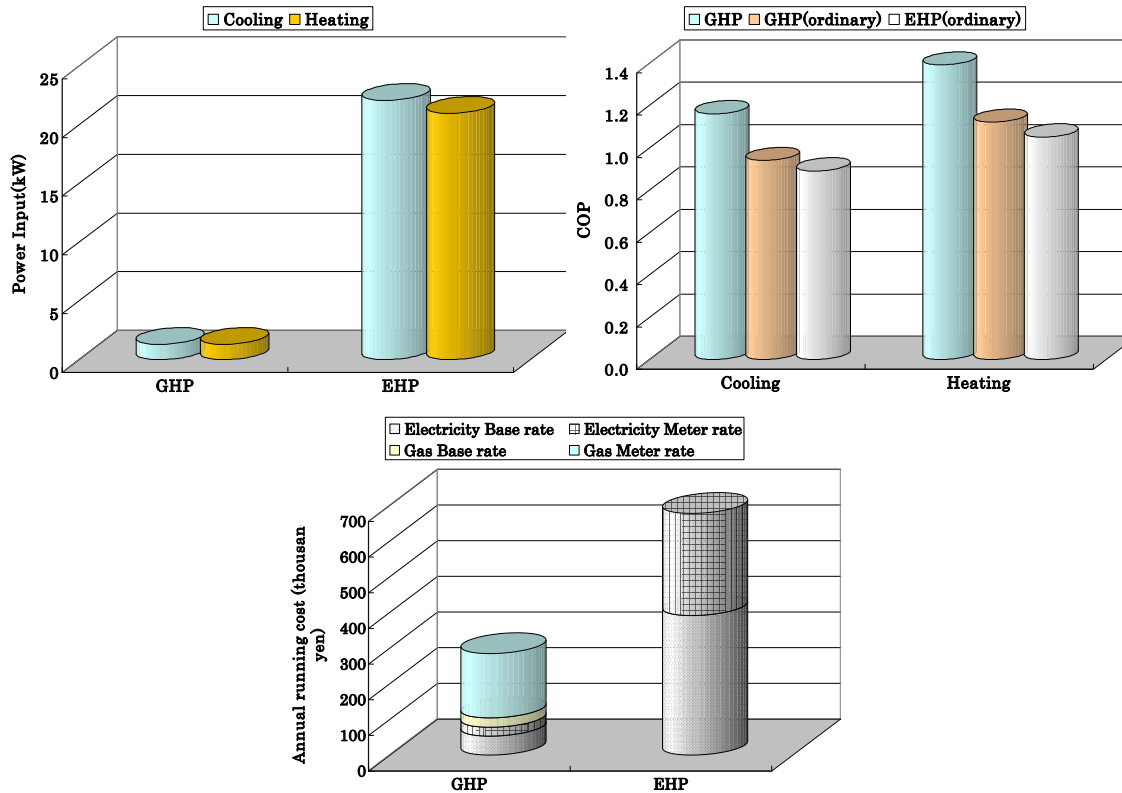


Figure 8 Comparison EHP vs GHP

#### 4. Prospect of GHP

##### ● Higher efficiency (lower energy consumption) and less nitrogen-oxide emission

As previously mentioned, research and development are under way to reach higher efficiency and more energy-saving to contribute to environment preservation.

Followings are the two main points

##### (1) Improving refrigeration circuit

- Increase the theoretical refrigeration cycle efficiency by idealizing the flow of refrigerant
- Increase the heat exchanger efficiency
- Increase partial load efficiency

##### (2) Improving gas-fired engine

- Improving incineration
- Enhance engine's thermal efficiency by designing ideal caliber shape and adopting lean-burning process (30 to 32 % improvement)
- Emission of nitrogen-oxide became possible by adopting lean-burning process, idealizing igniting timing and adopting EGR (exhaust gas re-circulation system).
- Succeed in 200 minus ppm nitrogen-oxide emission (12-mode measurement method)

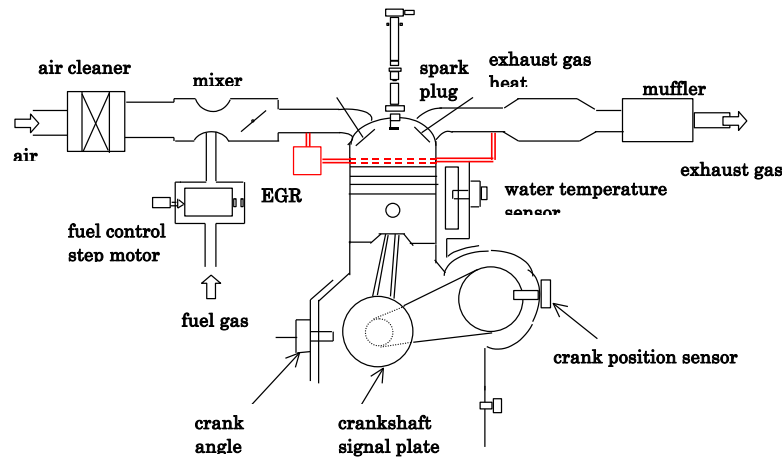


Figure 9 Principle of EGR (Aisin Seiki Co., Ltd. material)

### ● Adopting new refrigerant

According to the data gathered by the Air-conditioning equipment manufacturers' group of Japan, 93% of all the EHP installed in shops and small offices use HFC as their refrigerant. Replacement of refrigerant to 407C type will advance. As of January 2002 majority of the newly built GHP adopt new refrigerant.

### ● Meeting customer needs

As previously mentioned, answering clients need is the key to promoting sales as well as designing energy saving and low operating cost appliances.

Perhaps saving installation cost is the most important. Replacing the whole system including refrigerant pipe will accompany construction work. This will result to higher replacing expenses. Re-use of existing refrigerant pipe will solve this problem. This is where Geo-Multi comes in.

### (Example 1)Geo multi-system

This system reduces replacing cost by using existing refrigerant pipe. Refrigerant is replaced to a new type at the time of replacing air-conditioning appliances.

Well mixed refrigerant lubricant oil (old and new) will prevent system's malfunction caused by undissolved solid materials.

If replacing EHP, the new system will contribute to the reduction of electricity, and the replacement expense is saved.

What's typical about this system is that it does not need refrigerant lubricant oil. This system uses pressure differences which occurs in refrigerant heating-cooling process instead of motive power.

The system adopts HD (heat drive) method. This system has 2 heat drive tanks switching over to each other to circulate refrigerant. This enables the system to adopt variety of in-door equipment and is easy to install.



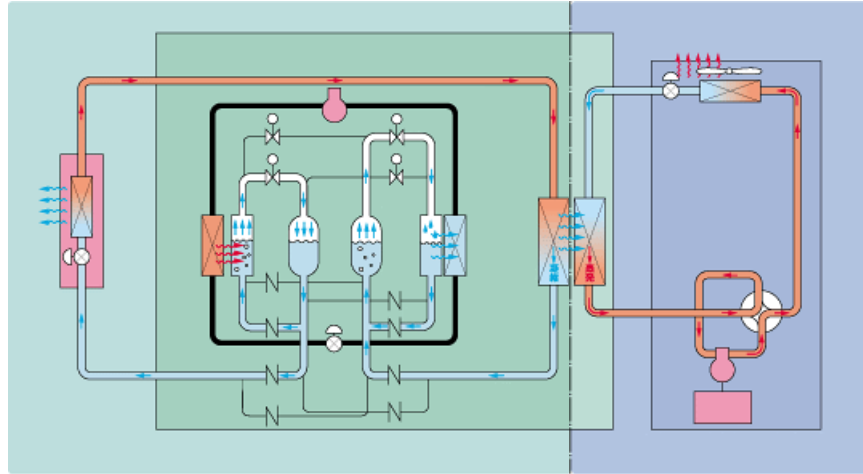


Figure 10 Geo multi-outline illustration (Daikin material)

### (Example 2) Simultaneous Heating-Cooling feature

In Japan, there are times of the year when both cooling and heating are required in the same building. Central air-conditioning system cannot meet this need and this is one of the reasons that local air-conditioning is widely used. EHP originally has system that enables simultaneous cooling and heating. Recently GHP system with this feature has been developed and brought into the market. Comparing to original model, the new model save up to over 50% of operating efficiency. This also saves installation space and consuming energy.

The new model also maintains advantageous features. This system can be used in colder climate areas where EHP cannot be installed. This will also contribute to electricity load leveling.

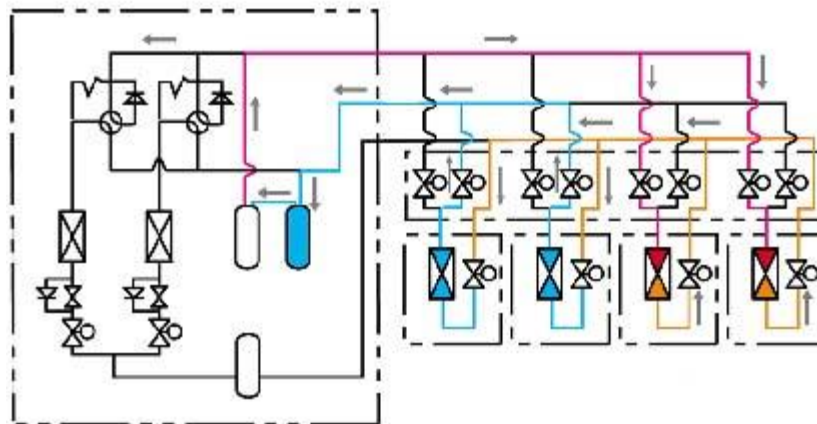


Figure 11 Multi-system with simultaneous Cooling & Heating capability (Mitsubishi material)

### (Example 3) GHP double multi-system

GHP is now widely used in many buildings. Installing many sets of system in single building requires operation that ensures every set of the system operate equally. Multi installation net-work system was invented to answer this requirement. Plural air-conditioners share the same refrigerant pipe. This enables the system to control the numbers of operating air-conditioners. This operation

saved up to 13% of energy consumption. Operating hours of air-conditioning appliances was reduced by 30%. In case of malfunction, with network system in place, others can back up the malfunctioned appliance.

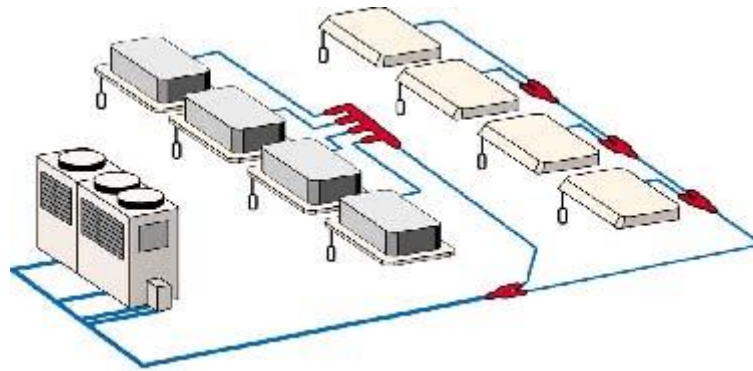


Figure 12 Outline of GHP double multi-system (Sanyo material)

## Conclusion

### ● Reasons why GHP system is used in many buildings

Sales and cost reduction efforts made by city gas company, and GHP manufactures, accompanied by variety of support from the government (favorable tax system, subsidizing installation cost, low interest rate loan)

Offerings of special discount of city gas rate have been succeeding in biting the share out of EHP.

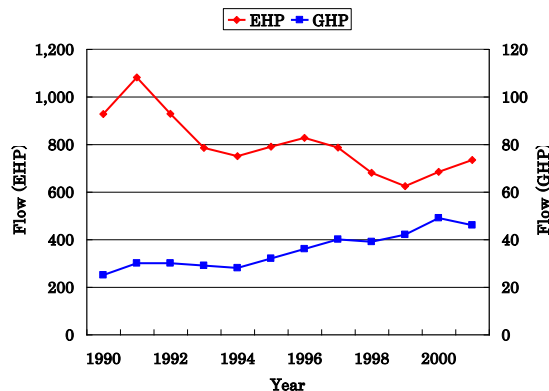


Figure 13 Air-conditioning market trend (EHP vs GHP)

### ● Future goal and problems to be solve

Energy saving will be further promoted. In government policies to promote energy-savings and global environmental preservation, application of so-called “top runner” method to air-conditioning system is the key to its success.

"Green purchase system" policy is taken by the government to introduce environmentally friendly and high efficiency system to the market.

We are determined to comply and contribute to environmental preservation policy by making every effort to supply the market with GHP that meets the requirement of the society.