# RESEARCH ACTIVITY ON HEAT PUMPS IN CHINA

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**ABSTRACT**

This paper describes the research activities and typical applications of heat pump development in China and outlines the current status of the industry in China.

**Key Words:** ***Heat pump, WSHP, GCHP, ASHP, Standard, China***

## 1 RESEARCH BACKGROUND

### 1.1 Opportunities for Development of the Heat Pump in China

Heat pump (HP) air conditioners have experienced a long period of slow development since the embryo model of the 1950's, due to unreasonable energy prices and other factors. The situation did not improve until the late 1970's, when a great chance for development arose. With the remarkable improvement in living standards and residence conditions, electric power supply, improvement in the marketplace and the construction of multi-floor buildings, the air conditioning and HP industry has been greatly improved... In addition, the promulgation and implementation of relevant policies and laws also provide new opportunities for the development of HP technology in China. These laws consist of "the law of energy saving," "the design standard of energy saving in civil construction," "the environmental protection policy of reducing $CO_2$ release, and the phase-out of CFCs refrigerant," etc. Furthermore, the adjustment of the energy framework and the reasonable energy price along with it, stimulated investment and electricity and the development of HP.

With these favorable factors, the development of HP enjoyed a great boom during the 1980's and the1990's. According to statistical data, the yearly production of room air conditioners, 60% of which were HP, was up to 15 million (including packaged ones) in 2001. The yearly output of air source heat pump (ASHP) chillers enjoyed a gradual rise from 1995 to 2000. A yearly yield of 7000 units in 2000, which accounted for 32.83% of the total production of central air conditioners, exceeded by far the yearly yield of 1195 units in 1995, which accounted for 10.75% of the total production. The rapid increase in the HP air conditioner market and the research and application of HP technology each promoted the other's development greatly.

### 1.2 Challenges in the HP Study

China has broad lands and different climates from latitude 3 to 53 degree north. For the popularly used ASHP, first of all, problems of defrosting control and the shortage of heat supply when temperatures are low in winter must be taken into account because the main characteristic of its

conventional application region, the Changjiang River drainage area, is mugginess in summer and clamminess in winter. Secondly, along with its northern expansion from the Changjiang River area to the Yellow River area after 1995, HP technology is faced with a difficult task to adapt conventional HP products to colder conditions and the development of new products.

The technology of the ground source heat pump (GSHP) is more complex than the ASHP, although it has high efficiency and abroad applicability. The obstacles, such as the design of heat exchangers underground and the fill-back technology of water source heat pumps (WSHP), would affect the result of the application of GSHP greatly. Thus, the research about GSHP has paid more attention to underground heat exchangers of ground-coupled heat pump system (GCHP).

## 2 RESEARCH ACTIVITY OF ASHP

At present, the ASHP is enjoying a large market in China, the product development of which is concentrated in the following fields:

- The application in cold climate: the HP manufacturers and institutes expend continuous effort to acclimate the ASHP units to the cold climate in north China. Just recently the Tinghua Tongfang Artificial Environment Co., Ltd. promoted innovative units that could maintain extraordinary EER of 1:2.3 in the atmosphere of -15 .

- The development of units with larger capacity: At present, the top cooling capacity of a homemade HP type chiller is 300~500 RT.

- The improvement of the performance coefficient: Large quantities of work have been done in this field, such as developing high COP compressors, optimizing the types of arrangements, running under the mix modes of single stage and double stage, equipping the HP units with heat recycle devices and evaluating the concentration and capacity of the refrigerants to achieve seasonal high COP, etc.

- Attempt to resolve the problem of defrosting: Researchers in China have taken into account the differences of defrosting in different climates. For example, one of them has proved the availability of fuzzy defrosting time fits for different climates by simulating its dynamic characteristics and experimental studies.

- Developing HP units that could provide hot tap water as a byproduct: A new tendency illustrated that the ASHP or GSHP could replace the conventional combination of chiller and boiler to afford the load of heating, cooling, and hot water supply at the same time. In the cooling season, the hot water could be available thoroughly, or at least partly, by recovering the condensing heat release, which could decrease the thermal contamination as well as save energy consumption. In south China, the indoor environment has to be cooled for more than five months a year and the condensing heat exhaust is consequently so considerable that this heat recovering system could become an economical choice in large commercial building such as hotels.

- The development of multi-type units: Although the Japanese brands, such as DaKing and Hitachi, have always played a significant role in the Chinese market, the domestic manufacturers of HP air conditioners, such as Haier, Gree and Medi, developed their own products of multi-type air conditioners on the basis of the technology of Japan companies, the original inventors of multi-type air conditioners. In early 2004, Haier presented new products of double converter multi-type units, a representative of the third generation central air conditioning units. This kind of products have been widely used to provide comfortable indoor thermal environment in many important projects such as the premier mansion of Greece, Zhongnanhai, and Chongqing air port.

## 3 RESEARCH AND APPLICATION OF WSHP

### 3.1 Application of Single-Well Recharge Technology

Beijing Ever Source Science & Technology Development Co., Ltd., an archetype of the WSHP manufacturer in China, has filed 75 patents for its WSHP system in China, the United States, and Europe as of April 2004. The initiating technology of single-well recharge type WSHP units, applied to buildings in late 2002, realized an application area of 1.5 million square meters and gave the company a tremendous distribution income of 300 million RMB (36.3 million US$) in 2004. The innovative system covers 75 % of the market share in Beijing, including the project of protecting the 35,000 $m^2$ outdoor water pools in the Chinese national theater from freezing in winter.

### 3.2 The Application of Different Well Recharge Technologies

At present the gradient utilization of the ground water began to be utilized in large central heat supply projects such as the 400,000 $m^2$ zone 6 of the Beiyuan homestead in Beijing. In this project, the original groundwater temperature is 68°C and the recharge water temperature reaches as low as 18°C after gradient application by HP. The heating load of this project is 25,000kw, and the geothermal ground water affords 4,012kw of the total. The HP could provide 5,988kw additionally so that this gradient system could satisfy 40 % of the gross heat demand. Additional heat supply by natural gas would have to be utilized to compensate for the heat shortage.

Furthermore, the ground water is widely used in the industry, such as tourism and hotels, so that better utilization of the geothermal water could produce favorable economic results as a reasonable consequence of continuing research and investigation...

## 4 THE APPLICATION OF GCHP

Currently, research work on GCHP in China is focused on dealing with heat exchangers underground by utilizing materials made in China and technologies developed in China on the basis of using advanced technologies of developed countries for reference. The application of GCHP in China is enjoying rapid progress and has also made outstanding progress in the Asia-Pacific region. A yearly increase of about 40~50 projects could be expected in China in next three years.

## 5 OTHER TYPES OF HP

### 5.1 Wastewater Source Heat Pump

The first application of a heat supply and cooling system using the wastewater source heat pump in China that could handle the heat load of buildings with an area of 8700$m^2$ was put into use in one of the wastewater treatment plants in Beijing in 2004.

### 5.2 Seawater Source Heat Pump

In 2004, the first project using a seawater source heat pump in China was set up in Qingdao power plant in ShanDong province. This system could handle the heat load of its mess hall with a total area of 1871$m^2$.

### 5.3 HP Utilization of Remaining Heat in Industry

Remaining heat in the process of industrial production is available in abundance in China. The ratio of the remaining heat to the total is 8.8 percent in the chemical industry, 30.9 percent in the petrochemical industry, and 4 percent in the spinning industry. In order to save energy, manufacturers of the petrochemical, paper mill, pharmaceutical plant, metallurgical plant, packinghouse and agricultural industries have conducted research and development work on the application of HP, for instance, recycling the remaining heat of the petrochemical plant by using steam jet type HP.

### 5.4 Development of the Standard and Regulation System of HP

In recent years, standards and regulations for HP units have been put in place gradually. Standards in practice include “Water source heat pump unit”(GB/T19409-2003), “Duct type air conditioner (HP) unit”(GB/T 18836-2002), “Multi-type air conditioner (HP) unit” (GB/T 18837-2002), “Chiller (HP) of steam compress circulation Chiller (HP) applying to industrial, commercial and similar fields”(GB/T18430.1-2001) and “Chiller (HP) of steam compress circulation Chiller (HP) applying to family and similar fields”(GB/T18430.2-2001), etc. National standards focused on the application of HP, “The technical regulation of heat supply and air conditioning using ground source HP”, is under compilation at present, and other reference material, such as “The consultation of the technology of ground source heat pump” has already been published. The whole industry of HP air conditioner in China is experiencing a course of standardization these years and a more flourishing and normative market can be anticipated in the future.