

HEAT PUMP IN CHINA

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Abstract: This paper gives a brief introduction of the national policies that have a great influence of the heat pump development and the major R&D work on this area, describes the market situation of the heat pump in 2006 and 2007 and lists the rating system and minimum allowable values of all types of heat pump in China.

Key words: *heat pumps, national policy, R&D work, market situation*

1 NATIONAL POLICY

In order to carry on the energy conservation and GHG reduction work in a sustainable way. Since 2005, the State Council revised <the People's Republic of China Energy Conservation Law>, published <People's Republic of China Renewable Energy Law>, promulgated <Mid-long term Development Plan of Renewable Energy >.

The <China's National Climate Change programme> which was published on June 3rd 2007 mentioned: Promote the development and utilization of geothermal energy and ocean energy actively; popularize the geothermal heating and hot water system and the Ground Source Heat Pump system which meets the environment and water resources protection requirements. Legal Office of the State Council solicited the opinion of <Energy-conserving Regulations of Civil Building (draft)> on June 27, 2007, it mentioned: the State Council encourage and support to utilize the solar energy and geothermal energy in newly-built buildings and existing buildings. Ministry of construction <Implementation Opinion about the < Decision about Enhancement Energy conservation Work by State Council > set the Working objective: In the end of the 11th –five year plan, the solar energy, the shallow ground energy and the other renewable energy application area should account for above 25% of the newly built floor space.

The Ministry of Finance and Ministry of Construction of China also released < Implementation Opinion about Promote the Renewable Energy Utilization in Building Application > and <Temporary Management Measures for Special Funds for Renewable Energy>. The following areas are strongly supported by the government:

- 1、 Heating and cooling with the water source heat pump in the Surface water and ground water rich area
- 2、 Heating and cooling with the seawater source heat pump in Coastal area
- 3、 Heating and cooling with Ground-coupled heat pump (Geothermal heat pump)
- 4、 Heating and cooling with sewage source heat pump

For the response of the country's initiative, several ministries and commissions, local authorities also formulate the corresponding policy of the energy conservation and building energy efficiency one after another, many cities have also provide special subsidies to encourage the application of Ground Source Heat Pump system.

For example, the Beijing government provides some financial support to those buildings that select heat pump systems according to their floor space measured by the Beijing Municipal Commission of Urban Planning. The grant is 35 RMB per sq meters for surface water heat pump system and 50 RMB per sq meter for GSHP and reused water heat pump systems. Dalian, a city in Northeastern China, has been selected as a pilot city of the application of seawater heat pumps after a series of applications and inspections. A heating and cooling

system of more than 5 million sq meters of floor space in the city will be provided by seawater heat pumps. The government will provide 70% of the cost from then on. Shenyang, the largest city in Northeastern China, has also made a detailed plan for the popularization of GSHP systems in the city. Almost all the new buildings of Shenyang constructed in 2007 used GSHP system for heating. Till now, there are more than 20 million sq meter of floor space utilized this technology just in this city.

According to the Chinese government's 11th Five-Year Plan, the aim is to keep average annual GDP growth at 7.5 % and reduce energy consumption by 4% each year. so the whole country pay more and more attention on the energy conservation and environmental protection, the building energy efficiency and the renewable energy utilization will become the hot point inevitably in the HVAC R&D and industry in the future. Still, energy and resource conservation and the reduction of CO₂ emissions are covered by a national regulation and standards that all companies must follow. In order to meet the requirements of the regulation, HVAC manufactures need to adjust their structures, prompt technical progress, strengthen management on energy-savings, reduce pollution, and follow the national standards.

2 CLIMATE CHARACRISTICS OF CHINA

Compare with other areas at the same latitude of the world, the winter temperature of China is somewhat lower, but the summer temperature is higher, the temperature annual range is bigger, the precipitation concentrates in the summer, these are the continental climate characteristics. Therefore China's monsoon climate, continental strong, also is called as the continental monsoon climate.

Along with the rising of the living standards, China's heating line moves south gradually, buildings in the Yangtze River area have the heating demand more and more .And nearly all the provinces in China in summer have the cold demand more or less, therefore the air source heat pump and ground source heat pump heating and cooling system can be utilized in nearly all parts of China.

3 MAJOR R&D WORK

Followed with the <National Medium and long-term Science And Technological development Plan > of the Ministry of Science and Technology, the Ministry of Science and Technology and the Ministry of Construction united all the national research organizations and corporations to promote the national science and technology R&D program < Key Technologies Research And Demonstration Guide of Building Energy Efficiency >, and has mainly developed the following research topics on the heat pump technology

Air Source Heat Pump

The Air Source Heat Pump have a wide range applicability and a small environmental effect compared with other technologies.

It is suitable for the majority region in China, but the northern area defrosts control problem and when the outdoor temperature getting lower the shortage of the heating capacity problem is urgently needed to be solved.

The major ongoing research activities are:

- 1、Technology of the heat exchanger that can reduce frost. Through change the heat exchanger structure, As well as uses the new material, to reduce the frost quantity and the performance influence of the frost to the heat exchanger.

2、 Intelligent highly effective defrost technique and defrost control technology. It is including frost condition measurement technology, new highly effective defrost technical process, highly effective defrost process implementation method and so on.

3、 Enhance the COP on the condition of wide range change of Temperature difference

With the methods like two-stage compression as well as the invariable compression ratio and so on, let the unit have a higher COP in the heating mode with the outdoor temperature between -10°C and 10°C and in the cooling mode with the outdoor temperature between 30°C and 40°C

Develop the air source heat pump with the capacity between 5 to 300KW. In the heating mode, with the outdoor temperature - 15°C and outlet air temperature 35°C, the COP of 5KW air source heat pump should be higher than 2.75; For the 300KW air source heat pump with the outdoor temperature - 15°C and outlet air temperature 40°C, COP should be higher than 2.48.

WSHP unit /GSHP system

In China, According to the difference type of energy exchange system, the Ground Source Heat Pump system including the ground-coupled (ground loop) heat pump system, the ground water source heat pump system and the surface water source heat pump system. Surface water includes: River water, lake water, sea water, city sewage and industrial waste water.

The major ongoing research activities are:

1、 Technical compatibility research

Doing research under the different water resources condition, the influence of extraction and rejection of the underground water to the underground ecological environment and the geological structure, determine technical key point of the well maintenance under the different resources condition, as well as application condition and applicable scope of the underground water heat pump system; Doing research on the influence of the ground source heat pump to geological environment, determine under different geological condition, different load characteristic , the application condition and applicable scope of the ground soil source heat pump system; Research ecology environment influence assessment method of the sewage, sea water and surface water heat pump system; Evaluation system of the GSHP

2、 Ground-coupled HP system

Heat transfer model of the heat exchanger and measurement method of the soil characteristic; computational method of the heat transfer coefficient under different distance of the boreholes.

3、 Ground Water Source HP system and the Surface Water Source HP system

Energy efficiency optimization design method of the ground water, surface water source heat pump system; heat transfer model of the closed type surface water heat exchanger; software that can analysis the ground water, surface water source heat pump system

4、 Sewage, Sea Water Source HP system

Water extraction equipment and the heat transfer technology of the sewage, the sea water source heat pump system

5、 Water Source HP unit

The development of the water source heat pump unit that can adapt highly effective to the GSHP system, including water-air HP unit with the cooling capacity under 100kW and the water-water heat pump unit with the cooling capacity above 150kW. Under the testing requirement of the National standard < water source heat pump unit >, water-air HP unit with the cooling capacity under 100kW, COP should above 3.9 (underground water) or 3.4 (soil) in the heating mode and should above 5 (underground water) or 4.9 (soil) in the cooling mode, water-water heat pump unit with the cooling capacity above 150kW, COP should above 4.6 (underground water) or 4.0 (soil) in the heating mode and should above 5.9 (underground water) or 5.7 (soil) in the cooling mode

CO₂ Heat Pump Water Heater

Whether HCFC should be eliminated earlier is being disputed at present. But researches of the natural refrigerant of the heat pump have already being launched gradually

The main research focus on the domestic HP water heater, simultaneously may consider integrating it with the home-used air conditioner. Develop series products with the capacity from 80 liter to 200 liter, takes the heat from the room or outdoor air, prepares 55 to 60 degree hot water and COP should be no lower than 4.

3.4 ASHP for the residential use in Yangtze River area

To develop air source heat pump unit that can produce 35 °C hot water in winter and 15 °C cold water in summer and it can also work as a dehumidifier that can produce dry air lower than 9g/kg. This unit with the COP higher than 4 can meet all the HVAC、dehumidification and fresh air requirement in this region comprehensively.

4 MARKET SITUATION

Real estate construction has been developing very fast in recent years in China. About 1.5 to 2.0 billion sq meters of floor space was finished each year. Space heating accounts for 65% of the energy consumption of the buildings and in the cold regions such as Northeast China, space heating is needed for 4-6 months every year. These factors have provided excellent opportunities for heat pump system.

4.1 Room Air Conditioner

Heat pump ACs make up about more than 80% of the RAC market in China. The price of the heat pump RAC is close to that of the cooling only products. Also, their performance has greatly improved. So, heat pump ACs have become popular even in cold areas such as Northern China and Northeast China. 23.2 million ACs were sold in the domestic market in 2007, a 15.0% growth compared with the 20.2 million in 2006. Hot weather in the summer is one of the most important reasons for the sale growth.

4.2 Package Air Conditioner

There is no data of the Package Air Conditioner market, but it is estimated that more than 85% of the PAC can work as a heat pump.

4.3 Heat Pump Water Heater

Although as a new member of the heat pump family, the heat pump water heater has been developing rapidly in China in recent years. Manufacturers of this product include large-scale home appliance makers, solar energy water heater manufacturers, central AC makers and

others, relevant national standards will be released in the near future.

For the more than half billion people who live in the urban areas 70% of the family dwellings are equipped with water heater, One resource in 2006 indicates that the 3 traditional types of water heaters, gas water heater\electric water heater\solar energy water heater, still dominant the market, with only 0.58% of the market now, HP water heaters are still try to find the position. 72,000 were sold in the market in 2007, a 70% growth for the commercial use and 30% growth for the residential use compared with 37 , 000 in 2006. The total market for water heater was 11,550,000、 11,800,000、 12,500,000 in 2005-2007 and the heat pump water heater account for 0.13%, 0.31%, 0.58% of the whole market , It is estimated that the he heat pump water heater market could reach to 310,000 in 2010.

4.4 Multi-connected Air-Condition (heat pump) unit

The total turnover of the Multi-connected Air-Condition (heat pump) unit reach to 10 billion RMB in 2007 compared with 5.8 billion RMB in 2006, including 60% for the commercial use and 40% for the residential use.

4.5 WSHP unit/GSHP system

Based on the data collected by the Ministry of Construction, the application area of Ground Source Heat Pump system reach to 26.5 million sq meters floor space by the end of 2006 and it is almost tripled to about 80 million by the end of 2007. The Ministry of Finance have a subsidy about 700 million RMB for the 212 pilot projects all the nationwide.

GSHP has become notably popular as an efficient technology for energy-savings and CO2 emission reduction in buildings. This technology had been used in several projects that have a great influence in China. the Olympic village used the sewage water from a water-treatment factory 3 miles away from the village to support the heating and cooling demand of 393,000 sq meters floor space; and the National Center for the Performing Art used ground soil as the energy storage plant, use the water to balance the heating and cooling demand of the building; World Expo 2010 in Shanghai will have a pilot project that use the water from the Yangtze River to heat and cool the building.

5 RATING SYSTEM AND MINIMUM ALLOWABLE VALUE OF THE HEAT PUMP

In order to prompt energy-savings, Chinese government has regulated energy efficiency grades for RACs, PACs and multi-connected air-condition HP unit and the water source heat pump unit.

5.1. Room Air Conditioner

With the testing requirements of the <The minimum allowable values of the energy efficiency and Energy efficiency grades for room air conditioners> (GB 12021.3 - 2004), the Energy Efficiency Ratio (W/W) of the RACs should be no lower than the following form:

Table 1: energy Efficiency Ratio requirement of the Room Air Conditioner

Type	Cooling Capacity /W	Energy Efficiency Ratio (W/W)				
		5	4	3	2	1
Integrate system		2.30	2.50	2.70	2.90	3.10
Separate system	CC≤4500	2.60	2.80	3.00	3.20	3.40
	4500 < CC≤7100	2.50	2.70	2.90	3.10	3.30

	7100 < CC≤14000	2.40	2.60	2.80	3.00	3.20
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5.2 Package Air Conditioner

With the testing requirements of the <The minimum allowable values of the energy efficiency and Energy efficiency grades for package air conditioners> (GB 12021.3 - 2004), the Energy Efficiency Ratio (W/W) of the PACs should be no lower than the following form:

Table 2: Energy Efficiency Ratio requirement of the Package Air Conditioner

Type		Energy Efficiency Ratio (W/W)				
		1	2	3	4	5
Air cooling	ductless	3.20	3.00	2.80	2.60	2.40
	duct	2.90	2.70	2.50	2.30	2.10
Water cooling	ductless	3.60	3.40	3.20	3.00	2.80
	duct	3.30	3.10	2.90	2.70	2.50

5.3 Multi-connected Air-Condition (heat pump) unit

With the testing requirements of the <The minimum allowable values of the IPLV and energy efficiency grades for multi-connected air-condition (heat pump) unit>, the IPLV should be no lower than the following form:

Table 3: IPLV requirement of the Multi-connected Air-Condition (heat pump) unit

Cooling (Heating) Capacity /W	IPLV(C)、IPLV(H)(W/W)
≤28000	3.00
28001 ~ 84001	2.95
≥84001	2.90

5.4 Water Source Heat Pump unit

With the testing requirements of the <Water source heat pump unit > (GB/T 19409 - 2003), the EER and COP should be no lower than the following form:

Table 4: EER and COP of the water-air HP

Cooling capacity Q/W	Energy Efficiency Ratio (W/W)			Coefficient of Performance (W/W)		
	Water loop	ground water	Ground loop	Water loop	ground water	Ground loop
Q≤14000	3.20	4.00	3.90	3.50	3.10	2.65
14000 < Q≤28000	3.25	4.05	3.95	3.55	3.15	2.70
28000 < Q≤50000	3.30	4.10	4.00	3.60	3.20	2.75
50000 < Q≤80000	3.35	4.15	4.05	3.65	3.25	2.80
80000 < Q≤100000	3.40	4.20	4.10	3.70	3.30	2.85

Q > 100000	3.45	4.25	4.15	3.75	3.35	2.90
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Table 5: EER and COP of the water-water HP

Cooling capacity Q/W	Energy Efficiency Ratio (W/W)			Coefficient of Performance (W/W)		
	Water loop	ground water	Ground loop	Water loop	ground water	Ground loop
Q≤14000	3.40	4.25	4.10	3.70	3.25	2.80
14000 < Q≤28000	3.45	4.30	4.15	3.75	3.30	2.85
28000 < Q≤50000	3.50	4.35	4.20	3.80	3.35	2.90
50000 < Q≤80000	3.55	4.40	4.25	3.85	3.40	2.95
80000 < Q≤100000	3.60	4.45	4.30	3.90	3.45	3.00
100000 < Q≤150000	3.65	4.50	4.35	3.95	3.50	3.05
150000 < Q≤230000	3.75	4.55	4.40	4.00	3.55	3.10
Q > 230000	3.85	4.60	4.45	4.05	3.60	3.15

6 CONCLUSIONS

During the last three years, Central government of China promulgated a series of policies and regulations about the energy conservation and environmental protection and so as the local government, the whole nation pay more and more attention on the energy efficiency and renewable energy utilization, the heat pump technologies which can provide both heating and cooling for buildings is becoming more and more attractive so the market is getting bigger and bigger. During to the fast development of the Real estate construction and the economic growth and the rising of the living standard of people, China will be the world largest market for heat pump technologies inevitably.

What we need to take into consideration today is to find a solution that can achieve balance in economic growth, energy security and environmental protection. Therefore we should advance the technologies for energy-efficiency improvement of equipment and systems and find environmentally friendly refrigerants and systems.

It is also expected that IEA heat pump program will contribute, as a measure for promoting

international collaboration, to the development of heat pumping technology with more active involvement of countries from China.

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