GWSHP SYSTEM DESIGN OF BEIJING CONCORDIA PLAZA

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Abstract Introduces design of the center air conditioning system of Beijing concordia plaza using the geothermal water source heat pump. Compares primary investment and running cost with traditional center air conditioning system. Analyses the superiority of this system in using renewable energy source and saving energy etc.

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1.INTRODUCTION

Beijing concordia plaza, located in Beijing China, is a top grade residence type flat. Its floor area is 14175m^2 and total building area is 87949m^2. There are 32 stories on the ground and 3 stories underground together, and the structural height is 98m. This project consists of underground garage, the rooms for equipment, a clubhouse on the first floor and three tower buildings. The whole building was constructed from May 1999, and completed in the end of the year 2000. Because of the application of geothermal water source heat pump system in the residence type flat, it becomes one of cooperative demonstration projects of geothermal heat pump technology between China and USA.

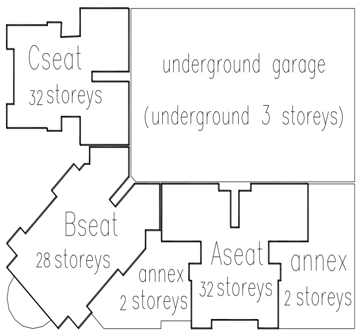

Figure1. Schematic plan

2.GEOTHERMAL WATER SOURCE HEAT PUMP SYSTEM DESIGN

The closed water loop heat pump center air conditioning system is adopted in the Beijing concordia plaza. Its total air conditioning area is about 70000m^2.

There are one or two heat pump units in every apartment, and the air system is all air system. The heat pump units installed in the clubhouse according to the function send processed air to every air-conditioned room.

Water pumped from deep well is used as exterior cold and heat source. 12～14℃ well water of 170m depth is used for providing cold and heat source to the water loop of WSHP through the plate heat exchangers. After heat exchanging, the well water is reinjected to deep well.

In the winter, the short of heat is supplemented by the hot water boiler of living.

2.1 COLD AND HEAT SOURCE

The total cold load of the Concordia Plaza is 4200KW, and the cold load quota is 64W/m^2. Its heat load is 3600KW, and the heat load quota is 51.8W/m^2. A set of center air conditioning system is adopted in this project. It supplies heat in the winter and cold in the summer. The constant temperature groundwater of saving energy and no pollution is adopted as the cold and heat source. Four wells of 170m depth are dug around the building, and the distance between two wells is about 120m. The pump rate of every well is about 200T/h, and the pipe diameter is 500mm. The accumulative total depth of available exploitation water layer of the four wells is about 35～40m. The static water level of groundwater is 18m, and the dynamic water level is 24m. According to the hydrology and geology material here, the extracted water temperature of well is 12～14℃, which is constant.

The four wells are cold and heat source of air-conditioning circulating water system. Water is drawn from two of them and the other two are used for pouring. A small groundwater ecology is formed in peripheral region of this building. To assure reinjection effect, the manner of pressurized reinjection is adopted.

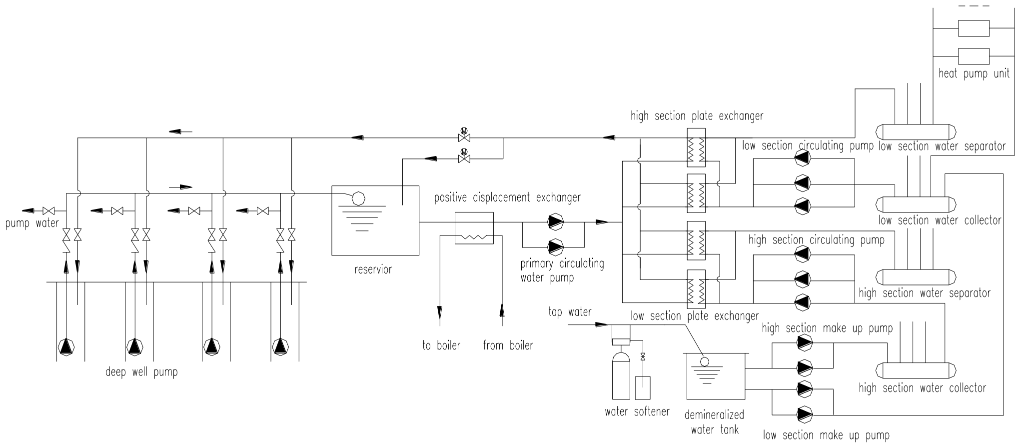

Figure2 Air conditioning water system elementary figure

The well water does the heat exchange with the loop of WSHP through the plate heat exchangers, and provides cold and heat source. In the summer, the extracted water temperature is 14℃, and rises to 22℃ after heat exchanging, and then is reinjected. In the winter, the extracted water temperature is 14℃, and drops to 8℃ after heat exchanging, and then is reinjected. If the extracted water temperature is under 14℃ in the winter, a standby boiler is worked as supplementary heat source. The temperature difference of pumping and reinjecting is 8℃ in the summer, and 6℃ in the winter. A deep well pump is installed in every well, it can draw and reinject. There is an available architectural space in the third storey underground, so we design a reservior. Water is drawn to the reservior by deep well pump, then is sent to the plate exchangers by the primary water pumps and exchanges heat with loop of WSHP. The frequency of the primary pump is changed according to the load of users. To make the most of cold of the deep well water, the primary water is returned to the reservior for circulating use when the part load. The water of reservior doesn't be reinjected until its temperature rises to a certain extent, that can economize the electric consumption of the deep well water pumps, reduce the quantity of pumping and reinjecting of deep well water, and extend the working life of the deep wells. The water system elementary figure of the geothermal water source heat pump system is shown like the figure2.

2.2 CLOSED CIRCULATING WATER LOOP DESIGN

The water source heat pump units are used in this building, and the air system is all air system. According to the using function, the heat pump units are installed respectively by the system in the clubhouse and natatorium. The units are parallel connection, which consist of the closed double pipe loop system and do the heat exchange with the heat source through the plate heat exchangers. In the summer, the inlet temperature of water loop is 18～24℃, and the extracted temperature is 24～30℃. In the winter, the inlet temperature is 12℃, and the extracted temperature is 6℃. The closed loop circulating water system is a constant volume double pipe different course system, which is divided into two pressure sections in 16th storey along the erect direction and pressurized respectively by the variable frequency pumps.

2.3 INDOOR AIR CONDITIONING SYSTEM DESIGN

One or two units are installed in every apartment according to its area and plan. The units are installed on the ground or in the ceiling. All air system sends cold and heat air to every room through air ducts. According to the architectural condition and operational requirement, the air returns through air ducts or gaps of door. Considering the less ventilation volume in dwelling house and opening windows at any moment, there is no fresh air system from the viewpoint of economy. The fresh air enters into the house via gaps of the windows.

To guarantee minus pressure in washrooms and bathrooms, the ventilators will be turned on while the heat pump units are working, which prevents peculiar smell flowing to other rooms.

To guarantee the noise requirement of dwellers, the wind speed in the air pipes is under 4m/s, and is under 2.5m/s on the air ports. The air pipes is made of anechoic fiberglas. The sending air pipes of heat pump units have noise elimination by noise elimination elbows or codistors. The heat pump units are deal with vibration damping and the device rooms are sound absorption and insulation.

3.CHARACTERISTICS OF GEOTHERMAL WATER SOURCE HEAT PUMP SYSTEM

There are two characteristics of the GWSHP system different from traditional air conditioning system:

①The cold and heat source is underground deep well water, different from traditional water loop heat pump system in which the cooling tower is abandoning heat device and the boiler is heating device.

②The air conditioning and heating devices are water source heat pump units.

These two characteristics have obvious advantages.

The technology of pumping and reinjection is used in cold and heat source, which has the following advantages:

①The cold and heat source is groundwater, which economizes floor space of machine room.

②Geothermal heat is reproducible source, which reduces environmental pollution brought on burning of oil and gas.

③The plate exchangers separate deep well water from the interior system, which avoids pollution to water source.

④The deep well water instead of cooling tower reduces condensation temperature and increases COP cost. When the cooling tower is adopted the inlet temperature of cooling water is 32.5℃, COP=3.07 and the inlet temperature of cooling water is under 25℃， COP⩾3.6 when the deep well water is adopted, which is favourable for energy saving.

⑤The deep well water instead of cooling tower eliminates noise pollution of cooling tower and reduces loosing of rinsing water.

Using the WSHP units as the air-conditioning and heating equipment in dwelling house has the following incomparable advantages with traditional electric refrigeration air-conditioning system.

①Detached ammeter, to measure in term of door, which is convenient for realty management and energy management. The users only need share in minute apportioning cost. The single system more inspires users with latent desire of energy saving, which is more favourable for the users of regular evection or lesser time of residence.

②The time of residence of users is different, and the time of using is different as well, which has irregular character. Users control units independently and use it smartly. This system even can avoid occuring this status, which affects other tenements on account of trouble of one part system.

③To supply cold and heat in the same time for the different tenements. Because of part units are applied in the clubhouse and swimming pool, which brings part behalf of heat recovery and has advantages for energy saving, especially in transitional season.

④The running cost is reasonable, generic tenements can afford it. The estimation of running cost of air- conditioning and heating in entire year is 2.8￥/m^2•month, but the cost of centralized heating using coal gas is 2.5￥/m^2•month only in one heating season. The running cost of the later is that to apportion the cost of a heating season to 12 months.

⑤It is favorable for developer. Developer can purchase water source heat pumps by stages according to the sale status of floors. Don’t purchase units of unsold floors temporarily, which doesn’t effect using of other tenements.

4.TECHONOLOGY AND ECONOMY COMPARE

4.1 INITIAL COST COMPARE

In order to have comparability, compare GWSHP system with traditional air-conditioning system in air-conditioning and heating status of one entire year. The cold source in the summer of traditional air-conditioning system is water chilling units of electric refrigeration, and the heat source in the winter is oil burning boiler. The fan coilers are installed in the end of every door and the air-conditioning units are installed in common parts.

Only to compare equipment cost of the two systems, both not including the cost of equipment installation and labor cost. The area of air-conditioning and heating is 70000 m^2. The table 1 is the initial cost of geothermal water source heat pump system, and the table 2 is the initial cost of traditional air-conditioning system.

Table 1. Initial Cost of Geothermal Water Source Heat Pump System

Device Name	Quantity	Unit Price (10^4￥)	Total Prices (10^4￥)
water source heat pump	580	1.80	1044
plate exchanger	4	20	80
positive displacement exchanger	1	4	4
circulating pump	6	1.6	9.6
pressurized pump	4	0.25	1
softened water equipment	1	4	4
automatic control system	1	30	30
2T/h boiler	1	25	25
wind pipe system			150
water pipe system			68
cost of digging wells, pumps and pipelines system			150
sum total			1565.6

Remark：the boiler is standby, so it is not numberd in the cost.

Table 2. Initial cost of traditional air-conditioning system

Device Name	Quantity	Unit Price (10^4￥)	Total Prices (10^4￥)
water chilling unit 19XL450	3	145	435
cooling tower	3	27.6	82.8
circulating pump of refrigerated water	4	2.2	8.8
circulating pump of cooling water	4	2.8	11.2
2T/h boiler	3	25	75
primary circulating pump	4	0.35	1.4
secondary circulating pump	8	0.65	5.2
plate exchanger	6	10	60
fan coiler	2200	0.15	330
air-conditioning unit	8	15	120
water pipe system			100
softened water equipment	1	8	8
pressurized pump	6	0.25	1.5
automatic control system	1		50
sum total			1303.9

According to the two tables above, the equipment cost of the geothermal water source heat pump system from above two tables is:

15,656,000￥/70000m^2 = 224￥/m^2

And the equipment cost of the traditional air-conditioning system is:

13,039,000￥/70000m^2 = 186￥/m^2

Therefore, the geothermal water source heat pump system invests more 2,660,000￥ than traditional air-conditioning system. But it should be pointed out that the primary equipments of the former are import equipments, and the later are homemade or joint-stock equipments, so there is a price difference between them.

4.2 RUNNING COST COMPARE

In order to have comparability, compare running status of two systems in the summer and in the winter separately. The basic data of running cost are:

① Assume that the running days are 125 in a complete heating season and 90 days in the summer.

② The cost is accounted including fuel (light oil), charges of electricity, equipment depreciation and maintenance cost etc.

③ The boiler is standby in the geothermal water source heat pump system. It works rarely, so this part cost is disregarded.

④ The base of comparison is unit building area.

4.2.1 HEATING RUNNING COST COMPARE

The heat quota of this building in the winter is 51.8W/m^2, the heat consumption quota in the heating season is 22.94W/m^2.

The total heat consumption in the heating season is 68.82KW•h/m^2.

Table 3. Heating running cost in the winter

geothermal water source heat pump system	￥/m^2	traditional center air-conditioning system	￥/m^2
running cost of water source heat pump units	8.26	fuel cost of the boiler	19.15
charges of electricity of secondary circulating pumps	1.85	charges of electricity of circulating pumps	1.71
charges of electricity of deep well water pumps	0.44	running cost of fan coilers	0.81
charges of electricity of primary circulating pumps(frequency conversion)	0.22		

equipment depreciation cost	6.39	equipment depreciation cost	5.32
equipment maintenance cost	0.64	equipment maintenance cost	0.53
sum total	17.8	sum total	27.52

According to the table 3, the heating running cost of the geothermal water source heat pump system is less 35.3% than traditional center air-condition system in the winter.

4.2.2 AIR-CONDITIONING RUNNING COST COMPARE

The air-conditioning cold load quota of this building is 64W/m^2, the cold load coefficient is 0.6, the average cold load quota is 38.4W/m^2, the air-conditioning running days are 90, the average running hours are 12.5 every day, the air-conditioning cold consumption is 43.2KW•h/m^2.

Table 4. Air-conditioning running cost in the summer

geothermal water source heat pump system	￥/m^2	traditional center air-conditioning system	￥/m^2
running cost of water source heat pump units	3.58	charges of electricity of water chilling units	3.15
charges of electricity of secondary circulating pumps	1.33	charges of electricity of circulating pumps	0.64
charges of electricity of deep well water pumps	0.30	charges of electricity of cooling pumps and cooling towers	0.83
charges of electricity of primary circulating pumps(frequency conversion)	0.15	running cost of fan coilers	0.61
equipment depreciation cost	4.80	equipment depreciation cost	3.99

equipment maintenance cost	0.48	equipment maintenance cost	0.40
sum total	10.64	sum total	9.62

According to the table 4, the air-conditioning running cost of the geothermal water source heat pump system is more 10.6% than traditional center air-condition system in the summer.

4.2.3 TOTAL RUNNING COST COMPARE

According to the table 5, the geothermal water source heat pump system is superior to boiler of burning oil system in heating. It can economize on light oil of 447 tons and heating cost of 689,000￥ every year. The geothermal water source heat pump system is more 72,000￥ than water chilling unit system in the air-conditioning operating mode. Counting from annual total running cost, the geothermal water source heat pump system economizes 617,000￥ than water chilling unit + boiler of burning oil system. Therefore the 2,660,000￥ of the more elementary investment will be retrieved inside 4～5 years. At present, the charging policy according to the family measure is being carried out in Beijing, therefore, should still count 600,000￥ of the cost of every family calorimeter in the elementary investment of the scheme 2, so the more elementary investment than the scheme 2 should be 2,060,000￥, and it will just get the recovery inside 3～4 years.

5. CONCLUSION

In summary, the concordia plaza adopts the geothermal water source heat pump system, which possesses more superiority and benefit in saving energy, showing mostly in:

① Northern flat residence adopts water source heat pump system, which can heating and air-condition in all year, and it is flexible to install, and convenient to adjust, and comfortable degree is good, and can satisfy the different requirements of users, and realize the charging according to the family measure.

② This center air-condition system possesses the heat recovery function, the running cost is lower, and energy saving is clear. Weighting with the synthetical quota including such as elementary investment, running cost and energy consumption etc, this system is more superior than the traditional center air-condition system.

③ This system uses the deep well water of underground as the cold and heat source of the water source heat pump system, fully uses terrestrial heat latent energy, and reduces discharge of hothouse gas, and economizes the water source. It is favour for protecting the environment air quality, the environmental protection beneficial result is good.

④ Along with the raise of people's living standard, people have put forward the higher requirement with comfortable nature of residence. The geothermal water source heat pump system meets better this kind of requirement, and will have the vast development foreground at the application of the air conditioning and heating of the city residence.

Table 5. The running cost

		1 year						5 year					
		heating		air-conditioning		total		heating		air-conditioning		total	
		scheme 1	scheme 2	scheme 1	scheme 2	scheme 1	scheme 2	scheme 1	scheme 2	scheme 1	scheme 2	scheme 1	scheme 2
electric consumption	power consumption (10^4KWh)	209	49	104	102	313	151	1045	245	520	510	1565	755
	charges of electricity (10^4￥)	75.4	17.6	37.5	36.6	112.9	54.2	377	88	187.5	183	564.5	271
fuel	capacity of fuel (Ton)		447				447		2235				2235
	cost of fuel (10^4￥)		134				134		670				670
equipment depreciation (10^4￥)		44.7	38.1	33.6	27.9	78.3	66.0	223.5	190.5	168	139.5	391.5	330
maintenance (10^4￥)		4.5	3.8	3.4	2.8	7.9	6.6	22.5	19.0	17.0	14.0	39.5	33.0
total (10^4￥)		124.6	193.5	74.5	67.3	199.1	260.8	623	967.5	372.5	336.5	995.5	1304
difference (10^4￥)		-68.9		7.2		-61.7		-344.5		36.0		-308.5	

The scheme1: geothermal water source heat pump system The scheme2: water chilling unit + boiler of burning oil + fan coiler system

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