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The New Energy-Conservation Technology's Application of the Direct Use of the Low-Temperature Geothermal Resources

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ABSTRACT

There are rich geothermal resources in China; the North of China is especially the rich in low-temperature geothermal resources that can be exploited and utilized. This paper describes a geothermal district heating system, which is successfully meeting the needs of the hot users by using the technology of an insulated cistern and at the same time makes full use of the low-temperature geothermal resources. Through this project, the paper discusses the way to use the low-temperature geothermal fluid, analyze the system's thermodynamic performance and the investment and operating costs, and at the same time, puts forward the solution of the direct use of the low- temperature geothermal resource to promote China's energy saving and environmental protection technology development and applications.

1. INTRODUCTION

Hebei Province is situated at the Huabei Plain, located at Beijing and Tianjin's periphery, along the shore near the Bohai Sea. Renqiu is located at the middle of the Hebei Province, and is abundant in natural resources. Renqiu is one of the important petrochemical producing areas in China, for its mineral resource are predominantly petroleum and natural gas. The utilization of geothermal energy resources plays an important role during the urban development, especially the utilization of low-medium temperature geothermal resource where the hot water temperature is 40°C or 70°C. Because of the great benefits for the environment and the low operational costs, the utilization of geothermal resources has developed incredibly. In Renqiu, the geothermal resource is now widely used in space heating.

2. THE PROJECT BACKGROUND

The Yiyuan district is located in the city of Renqiu in the Hebei Province. A well has been drilled for this project. The temperature of geothermal water in this well is 70°C, with a design flow rate of 60 m^3/h. The geothermal water will be used for space heating. The area that requires direct heating in winter is 75,000 ㎡.

3. POWER AND ENERGY DEMAND OF HEATING AND DOMESTIC HOT WATER

3.1 Design Space-Heating Load

The Yiyuan district possess of 15,000 ㎡ of original residential buildings and 60,000 ㎡ of multifunctional buildings, which are newly built. The original residential buildings are of 6 floors, in which the terminal units have radiator heating. The multifunctional building has 12 floors, where the 1~2 floors are used for marketplaces and others for flats. The marketplace is 3,000 ㎡, in which the terminal units have radiator heating. The heating system of the flats includes a low area heating system, which is 9,620 ㎡, and a high area heating system which is 47,380 ㎡, in both of these the terminal units have floor panel heating.

Table 1 shows the Yiyuan district heat load statistics of the 75,000 ㎡ residential quarter.

3.2 Heat Production of Geothermal Well

The output temperature of geothermal production well is 70°C and its designated water output is 60 m^3/h. The design temperature of drainage is 40°C. The heat production of the geothermal well is about 2093 kW.

Table 1 : Yiyuan district heat load statistic of the 75,000 ㎡ residential quarter.

Heating system		Area of heat-supply service	Space-heating load data per unit floor area	Design heating load	Design temperature of Supply and return water	Design flow of heat-supply system
		㎡	W/㎡	kW	℃	m^3/h
Radiator heating system	Original residential	15000	50	750	70/50	32.25
	The 1~2 floors multifunctional	3000		150		6.45
Floor panel heating system	Low area	47380	40	1895	50/40	162.95
	High area	9620		385		33.1
TOTAL		75000		3180		

The concrete computation formula of heat production is as follows:

$$Q_d = 1.163 \times G \times (t_d - t_h) \quad (1)$$

Where,

Q_d the heat production of geothermal well, kW

G the design geothermal well water flow rate output, m^3/h

t_d the output temperature of geothermal well, °C.

t_h the design temperature of drainage, °C.

According to heat production data from geothermal well and the statistical results for the residential heating load, the geothermal well cannot satisfy the demand of the building design heating load, when the final drainage temperature is 40°C. Because the peak load is about 3180kW, it is considered to install heat storage tank, and save up the hot water for peak demand regulation.

3.3 The Heat Storage Tank

The concrete computation formula of the heat storage from the tank is as follows:

$$c \times \rho \times V \times (t_d - t_h) / (3600 \times T) = Q - Q_d \quad (2)$$

Where,

c the specific heat of water, 4.187kJ/(kg·°C)

ρ the density of water, $1000kg/m^3$

V the volume of the tank, m^3

T the hours that supply heat under design heating load, h

Q the design heating load, kW

According to this calculation, when the volume is $300m^3$, the heat that the tank stores is 25.12×106 kJ, which with the geothermal well can satisfy and amounts to 6.4 hours heating supply that under the design heating load.

4. CRAFT SKETCH

In order to satisfy the different demands with the different terminal heating units system, two heating systems are designed in the substation, the one serves as the radiator heating system, which is called the first-class heating system as the follows, the other serves as the floor panel heating system, which is called the second-class heating system as the follows.

The heat storage tank is divided into two small tanks through the heat preservation partition wall, one of them uses in the first-class heating system, with a volume that is designed as $30m^3$ that meets the water pump 5~10minutes rate of water pump; The other uses in the second-class heating system, with a volume designed at $270m^3$. When the geothermal water is pumped through the electric submersible pump that used for geothermal well and to wipe off the sands by the desander, all of the inflow to the tank is used for the first-class heating system. When this tank is filled, the redundant hot water will flood into the other tank that used for the second-class heating system through the overflow which on the partition wall.

The water supply pump is the electric submersible pump used for the geothermal well. With the analog tube, the water supply pumps may completely fill the heat storage tank. The radiator heating system's water supply pumps in the tank are used for the first-class heating system, pumping the hot water to directly supply the space-heating installations. The low area of the floor panel heating system water supply pump and the high area of floor panel heating system's water supply pump put in the tank that is used for second-class heating system. When the first-class heating system returns water, the high area of floor panel heating system return water and parts of the low area of floor panel heating system return water are fully mixed, the water will be pumped to the space-heating installation separately by the low area and the high area of floor panel heating system's water supply pump.

5. THE INVESTMENT OF SYSTEM

Table 2 shows that Yiyuan district geothermal utilization project equipment capital costs statistic.

Table 2: Equipment capital costs.

Sequence number	Heating equipment		Electric equipment	
	equipment	Investment cost (10^4yuan)	equipment	Investment cost (10^4yuan)
1	Electric submersible pump geothermal well	16.07	Electric power tank	1.50
2	Well head equipment	1.51	Variable frequency devices tanks	14.41
3	Desander	1.11	soft set-up tank devices installing	1.95
4	Water supply pump	10.90	Cable	9.92
5	Analog tube	2.88	Pressure and liquid-level transmitter	1.50
6	Strainer	0.38	Temperature transducer and controller	1.31
7	Valve and accessory	2.81	Motorized valve and correcting unit	0.79
8	Pressure gauge and thermometer	0.41	Steel pipe that plating zinc	0.47
9	Heat flowmeter	0.13	Others	0.05
10	Steel pipe that no gaps	2.81		
Subtotal		39.02		34.00
Total		73.02		

6. OPERATIONAL COST

The heating system annual operational cost includes electricity costs, workforce, amortization, maintenance, and management cost (see Table 3).

Table 3: Operational cost per year.

Item	Cost(10^4 Yuan)
Electric cost	24.08
Workforce, amortization, maintenance and management cost	33.75
Total	57.83
Operational cost per area：7.71yuan/㎡	

7. CONCLUSIONS

The Yiyuan district geothermal utilization project in Renqiu makes full use of the geothermal resource. Furthermore, it is extremely economically beneficial, protects the local environment and has also raised the local living standards. In addition to the successful implementation of the Yiyuan district geothermal utilization project, it has created a tremendous opportunity for geothermal expansion in Hebei as well as the rest of China.

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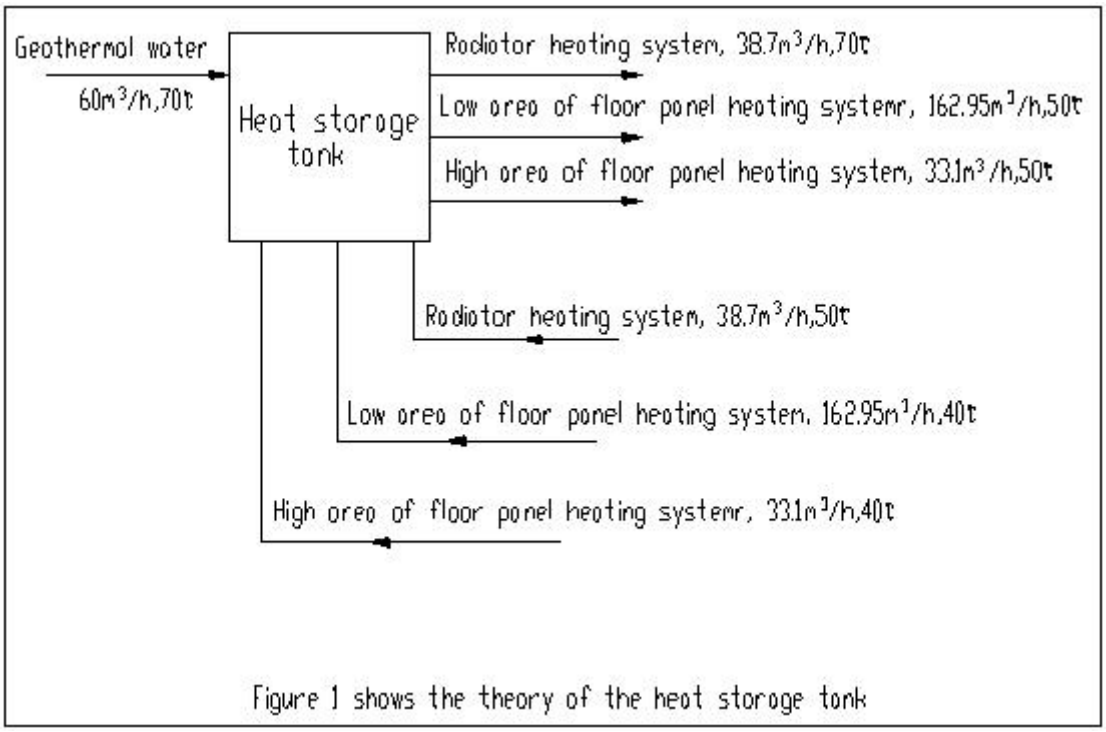

Figure 1: The theory of the heat storage tank.

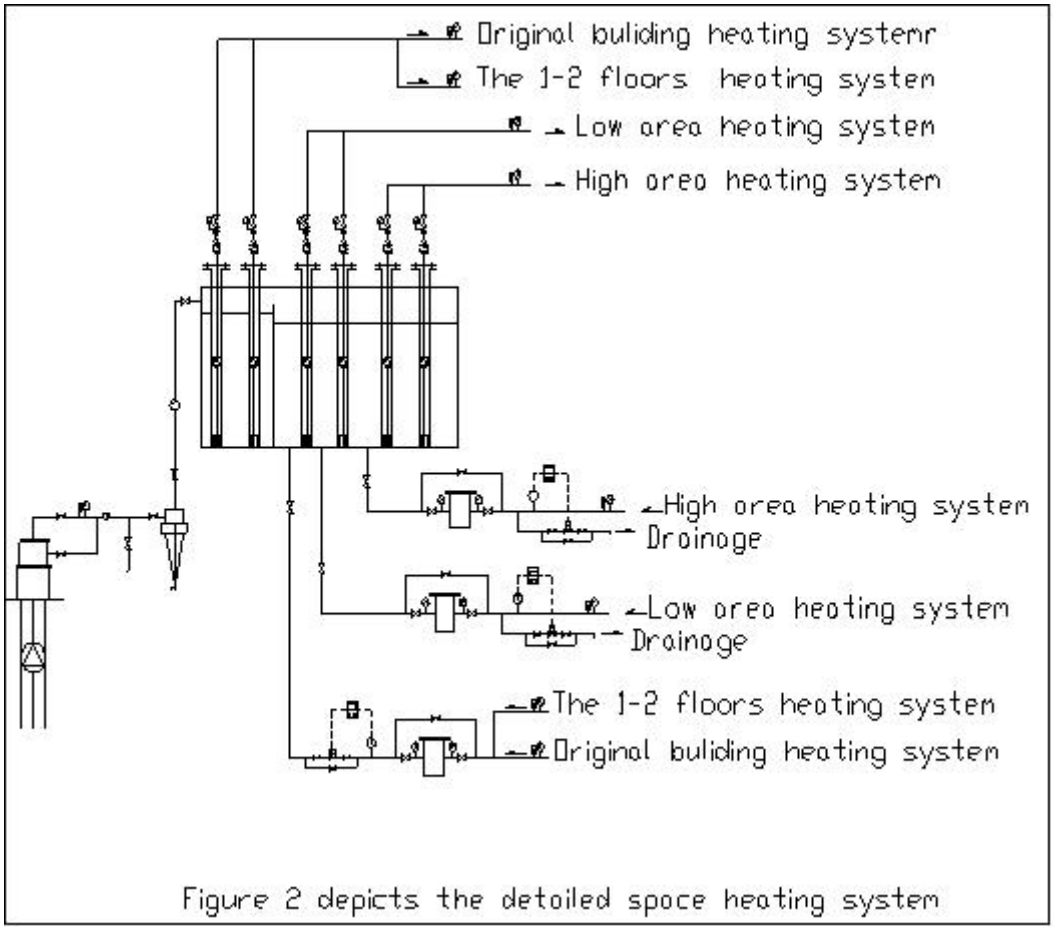

Figure 2: The detailed space heating system.