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INVESTMENT AND OPERATION ANALYSIS OF A GEOTHERMAL UTILIZATION SYSTEM IN TIANJIN

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ABSTRACT

This report describes a different approach to an existing district heating system project in Tianjin. The project is the newest model project in the geothermal utilization system in Tianjin at present. This system was established in 2007 and was designed as a centralized heat centre to cover the total heating requirement. In this report, we make a economic analysis for the geothermal utilization project using the circulation data of Hai-He Xintiandi, as well as analyse the investment and operating costs. The economical benefits allow for very high social benefits in addition. There are other models of the same kind all over the country.

1. INTRODUCTION

Tianjin is the largest open City by the sea in North China, and is one of the 4 municipalities directly under the Central Government of the People's Republic of China (Figure 1). Tianjin has abundant low-medium temperature geothermal resources, which cover about 8700 km^2. Geothermal utilization has developed incredibly fast because of the great benefits for the environment and the low operational costs. In Tianjin, geothermal resources are used for space heating, bathing, swimming pools, greenhouses, fish farming, medical purposes, physiotherapy etc. Geothermal exploitation plays an important role all over china. With the utilization in Tianjin in past 30 years, we have obtained certain experiences and achievements on model heating stations and servicing businesses, such as: drilling geothermal wells, manufacturing equipment, project design and construction. Furthermore knowledge has been gained on management organization and establishment of rules and regulations of geothermal

utilization. Consequently, Tianjin established the foundation of geothermal sustainable exploitation and utilization in the 21st century in China. This paper will analyze the investment and operational cost for the Hai-He Xintiandi geothermal utilization project.

2. THE PROJECT BACKGROUND

Hai-He Xintiandi is located in He dong District in Tianjin, close to the railway station. Three wells have been drilled for this project. The reservoir of Wells No. WR93D & WR93 belong to the JiXian System of the Wumishan group and WR92 is Ordovician. Wells No. WR93D & WR92 will be used for production and well No.WR93 for re-injection.

FIGURE 1: Location map of Tianjin, China

, the temperature of geothermal water in well WR93D is 80°C with a designated flow rate of 100 m^3/h and the temperature of well WR92I is 48°C with a designated flow rate of 47.33 m^3/h.

The geothermal water from Hai-He Xintiandi will be used for space heating and for domestic hot water. The area that requires space heating in the winter is 23.5×10^4 m^2, and domestic hot water should be supplied throughout the year from the Ordovician geothermal well (WR92).

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

Table1 shows the Hai-He Xintiandi heat load design statistic of the 23.5×10^4 m^2 residential quarter.

TABLE 1: Heating load

Item	High area load (kW)	Low area load (kW)	HVAC device
1st period residence	1254.3	2268.3	floor heating
2nd period residence	2593.7	4099.4	floor heating
subtotal	3848	6367.7	-
TOTAL	**10215.7**	-	-

Table 2 shows the Hai-He Xintiandi domestic hot water demand for the 23.5×10^4 m^2 residential quarter.

TABLE 2: Domestic hot water demand

Item	**Average demand（m^3/h）**	**Peak demand（m^3/h）**
Total residence	20	48.8

4. HEAT PRODUCTION OF GEOTHERMAL WELL

The output temperature of geothermal production well WR93D is 80°C and its designated water ouput is 100 m^3/h. After heat exchange with a plate and frame heat exchanger the geothermal water temperature declines to 40°C. The heat production of the geothermal well is about 4652 kW.

The concrete computation formula of heat production is as follows:

$Q= 1.163\times G\times(tg- th）=1.163\times100\times（80-40）= 4652kW$

Where,

- Q----- heat production of geothermal design well, kW
- G----- geothermal design well water flow rate ouput,m^3/h
- t_g-----geothermal output water temperature ,°C
- t_h----- geothermal tail water temperature after heat exchange, °C

According to heat production data from geothermal wells and the statistic results for the residential heating load, well WR93D cannot satisfy the demand of the building design heating load, when the geothermal tail water temperature is 40 °C. Because the peak load is about 5563.7 kW, it is considered to install water-source heat pump (WSHP), and recycle the returned water of 40°C for peak demand regulation.

5. CRAFT SKETCH

5.1 Space heating Systems

Space heating systems take advantage of the Wu Mi Shan group of geothermal wells. One well is a production well, the other are reinjection well. After heat production the geothermal water is reinjected. Geothermal well water is initially lifted by submersible pumps. After removing sand particles in sand eliminator, the water enters the plate and frame heat exchangers in the heat exchange

station, where circulating water for residential floor heating absorbs the heat from the geothermal fluid.

In the period of Jack Frost, when the outdoor temperature is lowest, the heat production by geothermal water cannot meet the indoor residential space heating demand, and system for regulating peak demand need to be set in motion. For example, the heat pump operating capacity can be regulated according to the heating load demand by reheating the circulating water of the heating system until it attains the water supply temperature of the heating design.

The heat produced by the geothermal water in heat exchangers is determined by a basic heating load and the heat production from heat pumps is used to regulate for peak demand. The source for the heat pump is the geothermal tail water. After heat exchanging, the geothermal water enters into an evaporator in the heat pump for reuse. Finally, the geothermal water is reinjected after heat has been absorbed and the temperature has dropped again after heat pump utilization.

Figure 2 depicts the detailed space heating system. Figure 3 the order of operation for the space heating system.

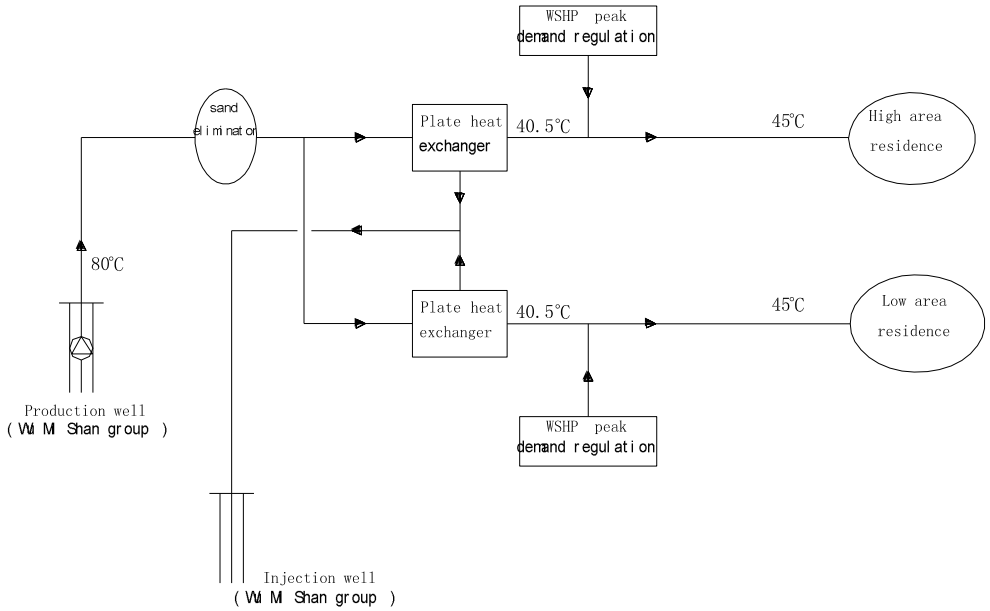

FIGURE 2: Schematic diagram of geothermal space heating system

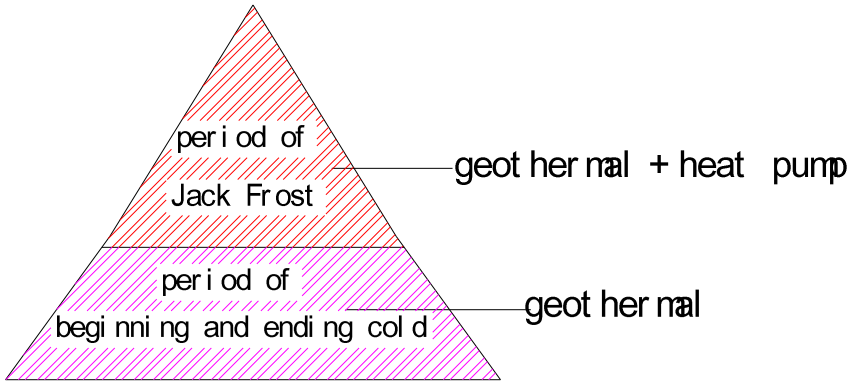

FIGURE 3: Schematic diagram of geothermal heating system

5.2 System of domestic hot water

The geothermal water is firstly exposed to pressurize hot, secondly it is pumped into an iron-eliminator. After filtrating and eliminating iron, the water enters the reservoir tank and finally it can supply hot water of 45°C to residential areas by a constantly pressurized water supply system.

In order to save on geothermal resources, life-hotwater needs to be returned to the reservoir tank. Moreover, to guarantee to satisfy the residential temperature demand for the life-hot water supply, heat from external sources can be complemented to the reservoir tank in periods without peak demand of by making use of hot water from the Wu Mi Shan geothermal well. See Figure 4 for the detailed diagram.

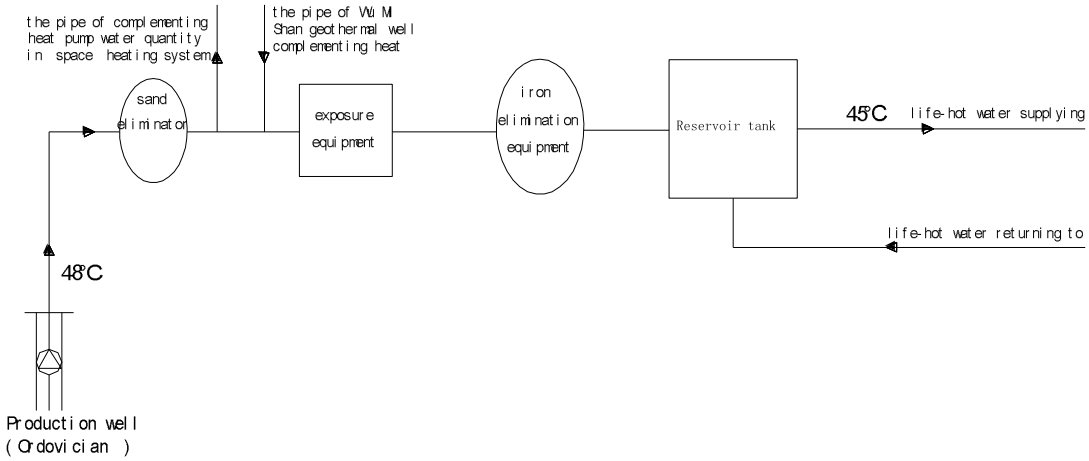

FIGURE 4: Schematic diagram of life-hot water system craft process

6. THE INVESTMENT OF SYSTEM

Table 3 shows that Hai-He Xintiandi geothermal utilization project equipment capital costs statistic (not including geothermal well construction costs and civil engineering costs of heat exchange station)

TABLE 3: Equipment capital costs

sequence number	**Equipment**	Investment Cost （RMB） **（10^4 yuan）**	**Electric equipment**	**Cost (10^4yuan）**
1	Water-source heat pumps	382.8	Cables and well tubes	4.45
2	Plate heat exchangers	197.7	Variable frequency devices and and variable frequency devices tanks	23.44
3	Water pumps	26.54	Variable frequency devices rebuiding	3.85
4	Quantity of heat meter	3.66	Soft start-up tank devices installing	0.68
5	Full-automatic soft water machine	6.8	Electric cable in electric power （using in heat pump）	27.56
6	Water processing equipments	11	low-tension tank	160
7	Wellhead devices and sand eliminators	3.8	Electric cable laying and installing	28.25
8	Reservoir tank (including heat reservation)	11.71		
9	Water separators and Water gathers	8.5		
10	Submersible pumps	7.6		
subtotal		660.11		248.23
TOTAL		**908.34 10^4yuan**		
Capital costs per area		38.7 yuan/m^2		

7. OPERATIONAL COST

System operational costs include geothermal resource development costs, freshwater supply costs, electricity costs (including the water pump and the water-source heat pump), workforce, amortization, maintenance, and management cost (see Table 4 and Table 5).

TABLE 4: Space heating operating costs per year

Item	**Cost (10^4yuan)**
Geothermal resource cost	21.31
Water cost	8.87
Electricity cost	206.59
Labor and amortization, maintenance, management costs	105.75
TOTAL	**342.52**
Operational costs per area	14.58 yuan/m^2

TABLE 5: Yearly Operational cost for Domestic hot water

Item	**Cost (10^4yuan)**
Geothermal resource cost	21.67
Electricity cost	28.25
TOTAL	**49.92**
Domestic hot water Operating cost	2.97 yuan /m^3

According to the date shown in the Table 4, the yearly operating costs for space heating are 14.58 yuan per square metre, when taking advantage of water-source heat pump for peak load demand regulation. This is only 1/3 of that for the gas fired boiler for peak demand regulation. Savings on operational costs can cover additional equipment costs for two years.

8. CONCLUSIONS

The Hai-He Xintiandi geothermal utilization project makes full use of clean geothermal energy and the sustainable development measures have been taken in order to protect the environment to provide more beautiful and comfortable environment for residents. Furthermore, it benefits not only the economy of other geothermal projects, but also the residential areas, creating a higher social standard.
In addition to the successful implement of the Hai-He Xintiandi geothermal utilization project, it has created a tremendous opportunity for geothermal expansion in Tianjin and the rest of China the Hai-He Xintiandi geothermal utilization project can be regarded as the model type for other projects all of the same kind in China.

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