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THE OPPORTUNITY AND RISK OF GEOTHERMAL HEATING INVESTMENT IN CHINA

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ABSTRACT

China has rich low temperature resources and an urgent need to develop district heating for meeting the needs of the market. There is an ever growing demand for the space heating and supplying domestic hot water in recent years in China. This paper is in the light of the Chinese practical experiences, briefly and specifically explains the factors of investment, Chinese general geothermal heating production processes, indexes, funds, risks and beneficial results assessment.

1. INTRODUCTION

China is the appropriate place to develop geothermal heating. There are many low temperature geothermal resources less than 90C in different parts of China. The proper development can make the resources renewable and protect the integrity of the environment. Ten years of low temperature geothermal heating development has accumulated much practical experience. Heating is a kind of public service and its demand has increased dramatically in recent years. This kind of consuming demands are highly cultivable and predictable. Market is the determinant factor of developing low temperature geothermal resources, and geothermal heating can become an independent industry. Because heating is the necessary demand of living, it has good market prospective and its technology is not complicated. Besides heating, maybe it is also possible to develop greenhouse cultivation and other industries as the leading enterprise in the countryside area.

The experience in China proves that geothermal development and utilization can obtain high economical, social and environmental benefits. Geothermal district heating has the advantage of previous development and long performance. Based on its economical development, the localities in China should analyze the recent changes in market demand. Localities should also relate the geothermal resources available, catch the opportunity to attract domestic and foreign high technology and apparatus, raise the geothermal utilization efficiency, set up geothermal heating industry, and obtain economical and social benefit.

2. CHARACTERISTICS OF GEOTHERMAL HEATING MARKET DEMAND IN TODAY'S CHINA

The residential areas in China have very high population density. The heating season in northern part of China is long. The area heating load rate is high.

Due to the growth of Chinese housing needs, the need for district heating is very high.

In order to improve the life quality, district heating is needed to replace the old type of dispersed coal heating of many houses.

The tourist industry, construction of swimming pools, and geothermal spas realize high economic profit.

The area demanding the construction of district heating is moving from North to South; from business buildings to domestic houses.

In order to protect the environment, the traditional coal fired boiler plants need to change to natural gas or oil heating. However, the cost of the change is rather high. This makes geothermal heating more competitive.

3. THE DIAGRAM OF A TYPICAL SYSTEM

The recent commonly used geothermal heating process includes in the heating season, submersible pump to increase geothermal fluid pressure, pass the fluid through meter and sand-remover device to titanium plate heat exchangers where the circulating water is heated. The heated water is then transmitted to the radiator or forced air fan coil terminal space heating equipment. If the peak heating is possible, the outgoing circulating water is reheated again in very cold weather. The cooled fluid is either surface disposed or injected. If part of geothermal disposed fluid is to be used for domestic hot water, most of them need an iron-removing process, then the purified fluid is stored in a tank to supply to the user. Figure 1 is shown a diagram of typical geothermal heating system.

4. THE INVESTMENT OF GEOTHERMAL HEATING

4.1 Drilling Cost

For commonly used 9 5/8 inch production casing and a 13 3/8 inch annular cased well, when the depth is around 2,000m, the market cost can be estimated by 1,250 RMB/m. So the total cost of a production and a reinjection well is 2,000*2*1,250 RMB/m=5,000,000 RMB.

8.30RMB ≅ $US1.00

4.2 Wellhead Cost

The wellhead devices include: submersible pump, wellhead sealing, sand-removers, and varible frequency devices. The estimated wellhead cost for a production and a injection well is about 0.7 million RMB.

4.3 Heat Exchanger Station Cost

For geothermal fluid indirect heating processes, the titanium plate heat exchanger is required to resist corrosion of geothermal fluid. The increased cost of heat exchanger and its installing is about 6-12 RMB/m^2 floor area.

4.4 Additional Cost of Terminal Radiator or Fan Coil

The commonly used terminal heat-releasing device is iron radiator now in China. In order to improve utilization efficiency and lower the temperature of cooled water, the area of radiator surface needs to be increased. Thus, the cost of radiators are increased. For the commonly used domestic radiator, the heat releasing capacity is determined by the temperature difference of the house inside air and the average temperature of the radiator. For example, for the commonly used cast iron four-column type radiator, if the design temperature of circulating water is tg_1=70C, th_1=45C, the required surface area of the geothermal heating system is F_1. Comparing with the required surface area F of the coal fired boiler plant heating system with the design temperature of tg_1=95C, th_1=70C for the same heat load, the number of the radiators used for a geothermal system should be doubled (F_1=2F). Thus, the additional heating device cost is about 10 RMB/m^2 floor area.

4.5 Fund Raising

In order to satisfy the rapid demand of the heating market. The Chinese heating industry has changed from a planned-economy and government subsidy to market fund raising and sole responsibility public utilities. The local government usually allowed the capable heat provider to charge the real estate developing merchant lump-sum payment for the development of heat resources. The standard charging rate is about 50-80 RMB/m^2 floor area. The money is used to build coal fired heat stations. In the geothermal heating system, the money is used to build geothermal heating stations. For 70,000 m^2 heating area and charging rate of 50 RMB/m^2, the total income is 3,500,000RMB. Furthermore, the income is nonrefundable.

If space heating of 70,000m2 floor area is supplied by a production well (capacity 100m^3/hr, temperature 70C), the initial investments are listed below:

- Drilling Cost: 5,000,000 RMB
- Wellhead cost: 700,000 RMB
- Heat exchanging station: 500,000 RMB
- Additional heat releasing device: 700,000 RMB
- Fundraising income: -3,500,000RMB

The estimated net investment: 3,400,000RMB

5. THE COST OF GEOTHERMAL HEATING

5.1 Peak Heating Cost

The peak heating measure is necessary for a geothermal heating system. Because of its high investment cost and low operation cost, a geothermal heating system is suitable for the base load. In contrast, a system incorporating peak heating has usually low investment cost and high operation cost, so it is suitable for a peak load and thus saves the accumulating fuel consumption. The peaking device can increase the utilization efficiency of geothermal resource and heating area.

In order to determine the appropriate peaking capacity, first the short-term and long-term peaking loads need should be investigated. Then, the local situation and environmental effect should be kept in mind. Then, the technology and money available is another factor that should be considered. In regard to the initial cost of a peaking device, heat category, and heat purchasing price, the appropriate means include: burning coal, gas, oil, and electricity. If the initial cost and heat-purchasing price are relatively low, the peaking capacity could be higher. In contrast, it should be lower. The possible range can 5%~50% of the designed peak load. It is here arranged at 30% of the peak load.

5.2 Operating Cost

For a production well of 70C surface temperature and 100m^3/h output, the typical cost of geothermal heating is considered initial investment cost I and Operation cost OC. The operating costs usually include: electricity cost, the resource fee of geothermal fluid, the assumption cost of peaking heat and etc.

- Resource fee 63,000RMB/yr.
- Electricity cost 126,000RMB/yr.
- Salary and welfare 50,000RMB/yr.
- Depreciation charge (20 yr.) 153,000RMB/yr.
- Maintenance cost 61,200RMB/yr.
- Miscellaneous and financial cost 20,000RMB/yr.
- Purchasing peaking-heat 140,000RMB/yr.

Amount of above OC= 613,200RMB/yr.

5.3 Annual Cost

In order to compare the economical effect of different projects, several methods can be used. In China, for the small heating project comparison, the present value method or the minimum annual cost method is used. When it is compared with the common energy project, because of their similar benefit content, so in order to simplify the calculation, the average annual cost method is most often used. In the method, the annual cost (AC) of the different projects are calculated and compared. The one with the lowest AC is the most economical project:

Higbee (1989) suggests that the general equation for the annual cost equation becomes:

AC=(A/P,i,n) (I-slvg) + i (slvg) + OC (5-1)

It is closed Chinese often used of projects estimate.

Where:(A/P,i,n) =i(1+i)n/((1+i)n -1) (5-2)

I initial investment cost

slvg salvage value

i interest rate per year

OC annual operating cost

In order to simply, due to the fact that salvage is small and slvg can be taken slvg=0

AC= (A/P, i, n) * I + OC (5-3)

When i=6 %, n=20, (A/P, i, n) equals 0.087185 and I =3,400,000 RMB, OC=613,200 RMB, in the formula (5-3) AC=909,629 RMB/yr. The unit cost equals AC/ floor area. So, AC/70,000 m^2= 13.0 RMB/m^2.yr.

6. THE MARKET AND INCOME OF GEOTHERMAL HEATING

6.1 The Price of Space Heating

In China, the price of space heating is based on the per square meter floor area of the building. The price is quite stable in recent years. It has been shown in table 1.

In the table 1, listed are three different regions: Xi-an located on the bank of the Yellow River, Beijing and Tianjin located in northern China, and Harbin and Da-qing locate in north-eastern China. Approximately, the Heating Degree Days (HDD) are calculated in the designed inside temperature of t_n= 18C, the base temperature t_b=14C considering the winter sunshine and the inside heat of the houses.

On the basis of HDD and designed unit average peak load q the unit area accumulating heat and unit thermal price of space heating can be obtained. For example, if q=60 W/m^2 in Beijing and Tianjin, unit area total accumulating heat are 384,000 KJ/m^2.yr and the unit thermal price equals (20 RMB/m^2.yr) /(384,000KJ/m^2.yr) matched unit thermal price 52 RMB/10^6 KJ.

There is a very close relationship of marketable residence space heating and domestic hot water consumption. The heating consumption in China has come to the primary development stage. The demand for the heating of public property is rising drastically. The space heating and domestic hot water supply are not an exclusive demand of public buildings. Residential district heating. is now a very important criterion for the house sales in the northern part of China. On the other hand, there is big difference in the demand for the district supplying of hot water and space heating in the different parts of China. Both the south and the north need hot water supply year round, but the demand is well related with the income status. Now, not only the hotels, some of the personal residencies have the demand of year round hot water supply as well. The demand is in a great changing period, so each place should consider their income level, analyzing the speed of the changes of the demand.

6.2 Space Heating Income

Let's assume that the output of one geothermal well capacity is 100t/h, temperature is 70C, the utilizing temperature drop for space heating is 25C, then the outlet fluid temperature after heating is 45C. Based on the above assumptions, the available heat is:

Q_d=100,000kg/hour * 25 K * 4.186KJ/Kg.k 6-1)

=2,907 kW.

If the heat consumption rate is 60 w/m^2 , then one well can provide the heat needed by the area

A_d= 2,907,000W/60W/m^2=48,450 m^2, which means that one well can heat an area of about 50,000m^2. If 30% of the heating peak load is afforded by peak heating, the heating area of this system will increase to 70,000 m^2. In this situation, the accumulated heat load of the peaking device will not exceed 10% of the total accumulating heat during a heating season.

Space heating income Hi=70,000m^2 * 20 RMB/m^2.yr (Beijing and Tianjin).

Business income Bi=Hi*Sp (6-2)

Sp sales value percentage, assumed Sp= 90%.

Gross profit PG= Bi - (Bi*Tb) - AC (6-3)

Tb business tax, assumed Tb=6%.

AC annual Cost

Net profit Pn=PG - (PG*Ti) (6-4)

Ti income tax.

The income tax Ti equals 0-30% of gross profit (income before tax), here taken 15%.

When I is 3,400,000 RMB, OC is 613,200RMB, i is 6%, n is 20 yr. AC=909,629RMB. The result net profit is

Pn =233,555 RMB/yr.

In fact, since underground deep fluid pressure is often slightly high in new geothermal fields and mostly the injection wells haven't been set up at present. The drilling cost can save half. If it is only a production well without an injection well, the initial investment will be 900,000RMB. The calculating result should be AC = 691,666 RMB/yr,

unit cost AC/A = 9.88RMB/m^2.yr.

PG = 492,734 RMB/yr,

Pn = 418,824 RMB/yr.

Sometimes the original old boiler plant can be used. The purchasing-heat became self-supply and with only payment of the fuel fee. The peaking-heat fee will be decreased more than half. In practice real investment and operating cost are usually lower than above listed for the most of geothermal heating projects.

6.3 The Income of Hot Water Supply

Geothermal fluid is rich in minerals. Most of the developed low-temperature mineral-rich geothermal fluid has proven helpful to the health when used for bathing, some can even cure disease. The resources will have high benefit if it is related with tourism and recuperation industry. The domestic hot water demand is year round, and it has even more economical benefit. Therefore, even in the Southern China, such as Fujian and Hainan, where the house heating is not necessary, low-temperature geothermal development has high benefit. In winter, geothermal water is first used for space heating, then for hot water supply, this is the common type of geothermal fluid utilization in China. The experience proves that it is appropriate, because hot water supply has more benefit. If supplying the fluid, removing the iron ion of fluid should be considered.

At present sale price is 4-5 RMB/m3 in the market. This part benefit hasn't been discussed.

7. THE RISK

7.1 The Risk of Well Drilling

Depending on the master of the hydrological and geological data drilling technology, the water output or temperature can deviate from the predicted situations in the drilling process or for the finished well. The risk is intensified for the new developing geothermal fields because of limited hydrological and geological data. In contrast, some places have more data from the drilling for oil exploration. In these areas, the risk is relatively low. As a matter of fact, the development of deep low temperature geothermal resources in China originated in the area with oil exploration drilling.

In the feasibility analysis, the resource risk should be considered as a disadvantaged and dealt with sensitivity analysis, thus the investment risk is reduced. In the operation, the investor may ask the geothermal well's designer and the drilling company to take the risk. In today's China, in most situations the risk is shared between the investor and drilling company, the details can be decided in the process of making contract.

7.2 Fast Decline of the Production Well

This can be caused by several factors:

- The reservoir's permeability and recharge ability are exaggerated during the drilling geological design.

- The discharge period of the new well is too short or there is misjudging in the discharge observation.

- Too many geothermal wells are located in a certain area, the exploit is too large, and there are not enough injection wells. This is a failure of resource management. Because of the fast developing pace of Chinese residential areas, the too fast resource depletion is the problem of many of China's geothermal fields. In fact, the risk could be reduced by improving management and intensifying the relevant law. Such as in Beijing city, geothermal management is quite a success.

7.3 Subsidence Risk

By observing subsidence caused by over exploitation, In Tianjin, geologists (Wu *et al.,*1998) indicate that the subsidence is mainly caused by the compression of the clay layer. Based on the observation of change of different layers, they found that the clay layer accounts for 77.6% of the subsidence and sand layer accounts for 22.4%. In the exploitation of geothermal water in the shallow deposit, the subsidence causes damage to homes, and water drainage system. So the exploitation of geothermal water in the shallow deposit layer should be very careful. Based on the experience in Tianjin, the exploitation of deep formation geothermal water causes very little subsidence.

7.4 Thermal Pollution

In order to meet the demand of space heating, the cooled geothermal water has still high temperature and the amount is large in bitter cold winter. The multiple use of the water is a way to solve the problem. For example, hot water supply, water sources heat pumps, hot water cultivation and etc.. When it is necessary, artificial fountains can be built in conjunction with the surrounding to realize water cooling.

The geothermal fluid capacity can be controlled by the vary frequency failing thermal pollution in non-heating season. At present in China surface disposal polluting the environment has often occurred due to a lack of an injection well. In some places, surface soil was salted and natural hot springs waste.

7.5 Management and Market

Chinese drilling cost and low temperature well operating cost are fairly stable. A large number of residences are multi-users in a pipe network district heating system. The market situation can't be changed failing risk of losing the market in recent years.

The thermal sales price, management and regulatory, interest and inflation rate are relatively stable. The risk is very little.

Comprehensive utilization industry compare with district heating the products marketable risk quite big. The risk is decide by products sales and isn't geothermal.

8. Conclusion

- The heating industry of deep low temperature geothermal resources requires high investment since stable thermal value and market output maybe high. Chinese requirements for district heating are a big market and increasing at a high rate, so there is more investment opportunity. It is still able to invest and get benefits in non anomaly geothermal regions. It has been proved in Chinese practice.

- Surface disposal causes thermal pollution, to reduce disposal or injecting temperature and raise geothermal utilization efficiency, the applied technology of giant water sources heat pump should be introduced at the right time.

- The injection wells should be gradually increased to cut down the risk of reservoir resource degradation in existing geothermal fields.

• The risks of drilling investment and resources sustainability are considerable. Early stages of projects should be handled with great care and strengthen the administration of resources to cut down the risks.

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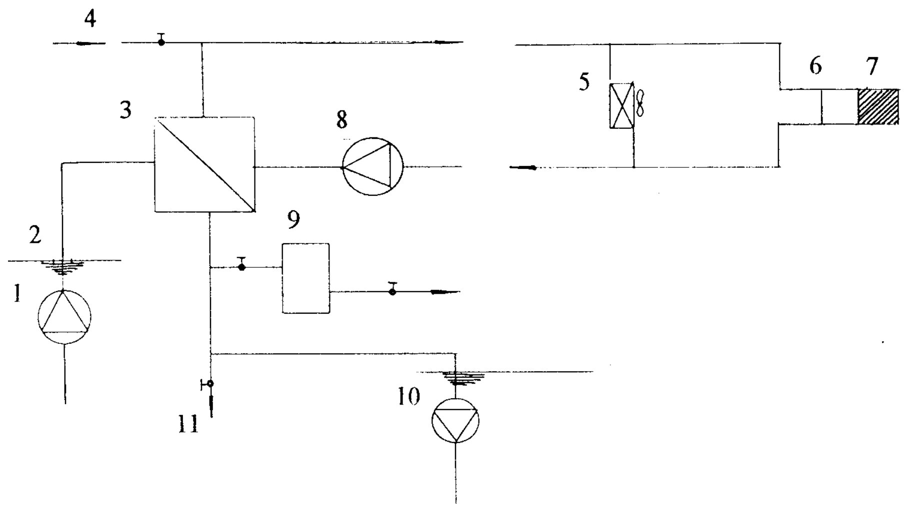

1.Submersible pump 2.Production well 3.Titanium plate heat exchanger 4.Peaking heat 5.Fan coil 6.radiator 7.Additional radiator 8.Circulating pump 9.Iron remover 10.Injection well 11.Surface disposal

Figure 1. A Diagram of Typical Geothermal Heating System.

Table 1. Heating Degree Days and space heating price 8.30RMB ≅ $US1.00

Region	Heating days	Heating Degree days	Space heating price
Unit	day	C.day	RMB/m^2 floor area
Xi-an	100-130	1500	15
Beijing, Tianjin	120-150	2000	20
Harbin, Da-Qing	180-200	4500	45