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STUDY ON FEASIBILITY FOR LOW TEMPERATURE GEOTHERMAL DISTRICT HEATING

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ABSTRACT

Thie paper describes the advantagee, the currently used ecale ae well ae the level for geothermal heating under the circumetancee in China. The utilization of low temperature geothermal climate conditione in Chineee citiee, and the main factore of impact on ueable temperature drop and their valuee for reference are analyeed. Taking the duelling area., North of Tianjin Atheletic Institute as an example, comparisons between two heat eupply projecte of low temperature geothermal and coal-burning boiler for their initial inveetment and annual production coet were made. Finally, the paper presents the geothermal gradient extent in which presently we can exploit low temperature geothermal resources in Chineee citiee.

INTRODUCTION

The western Pacific tectonic active zone goee through eaetern part of China. The whole China, particularly its eaetern part, are greatly affected by the Pacific Plate, thue there exist geothermal resources with temperature under 90°C in vast areae of China. Of the placee where we underetand better, there are euch areas like Beijing and Tianjin, North China, the Liăo-dōng Penineula, the Bóhāi Bay, as well as the region of Fújian and Guǎndōng.

For many yeare, placee along the Bóhāi Bay euch as Yingkou, Anehan and Xingcheng have exploited and utilized geothermal water of 50-80°C for heating and hot epring treatment of ills. The disparity in geothermal temperature is rather great in the North China region, there is, however, already coneiderable scale in the utilization of euch a resource.

The Songliao Plain of North-east China and North China Plain have been placee where industries in China are flouriehing, city populations are maeeing together, and the rather long period for winter heating exists. There is a bright prospect in exploiting and utilizing geothermal resources for the heating of city living quartere.

The geothermal low temperature limits ecope of ueage. Even in municipal areas where geothermal reeourcee are comparatively abundant, theee resources can hardly provide more than 3-5% of the total energy demand. Still, they contribute to a great extent the improvement of atmoepheric pollution of the duelling quartere of the citiee.

The large-ecale exploitation of geothermal resources will require coneiderable amount of inveetment. An analyeie should be made on the technical and economic poeeibilitiee and have it compared with the dietrict heating eupplied by coal-burning boilers that are generally in use in China. Such comparieion will provide a basis in making inveetment decisions.

ADVANTAGES OF GEOTHERMAL DISTRICT HEATING

Full and rational utilization of natural reeourcee may be obtained. By utilizing the low temperature geothermal water of less than 90°C for heating in place of fuele with chemical energy of higher grades, the waste of energy which may be traneformed into power will be greatly reduced, and there will be the leaet loss in exergy.

Reducing the air pollution of the type of coal smoke, bettering the quality of urban environment.

A eaving in fuele.

Raising the living level of the people. Ae no fuele are required with geothermal heat eupply, the heating eeaeon may start in correepondence with the requirement of human physiology, thus prolonging the heat-eupply eeaeon. Meanwhile, domeetic hot water can be served all the year round.

The exploitation of geothermal hae the advantages of period than the conetruction of coal mining, and getting beneficial effect readily.

CONDITION OF GEOTHERMAL SPACE HEATING

Scope of geothermal energy already utilized in varioue dietricte in China is ehown in Table 1.

Usually the geothermal epace heating is combined with the domeetic hot water. Geothermal water with a low temperature of 30-50°C is ueually employed in living, or in induetrial and agricultural production. Such areas are much more than thoee lieted in Table 1.

At present, the epace heating in China from geothermal mainly utilizes the heating equipment originally installed. The geothermal water flowe directly into the heating eyetem and provides heat from the radiatore. Upon diecharge, the water temperature drope by approxi-

Region	No.of welle	Water-temp. C	Depth of well □	Area of epace heating m²	
Beijing	55	33-69	650-2000	240,000	1986
Tianjin	169	30-96	600-2000	300,000	1986
Ren-qiu,He-bai Prov.				65,000	1986
Luda , Anehan, Xingcheng		55-73		Appr. 10,000	1979
Yingkou	3	82	169-559	13,000	1979

mately 15°C. As there is no peaking equipment, the rate of utilization is comparatively low. The People's Art Press in the Eaet-city Dietrict of Beijing may be taken as a typical example of geothermal water for heating. The conetruction of the well was completed in September 1974 with a depth of 1299 meters. The capacity of the water drawn amounts to 36 ton/hour, with wellhead temperature at 59°C. The area supplied totals 15,000m² ,on which there are 8 buildings. In addition, there is a eupply of domeetic hot water for use in public bath, hospital, etc.

As the number of users of the geothermal epace heating is increasing these yeare, the corrosion of eyeteme becomes acute and is being tackled. Peaking boilers have inetalled. Heat exchangers made of stainless steel or titanium plate have been eet up in a few eyeteme, and this aggravate6 the inveetment consider-ably.

CLIMATIC CONDITIONS

There are only a few odd places eouth of the Yangtze River in China where winter heating is necessary.Almost all places north of the Yangtze River require epace heating. Still, the length of the heating eeaeon and the factor of annual utilization ehould be taken into coneideration in developing geothermal water for the purpoee of space heating. In the way recommended by Steadman, a table of Heating Degree Days is drawn up and calculated by the monthly averaged temperature.

Table 2 H.D.D. of Citiee of China

Region	Harbin	Changchun	Huhehot	Xi-ning	Shenyang
H.D.D.	5547	5056	4663	4451	4145

Region	Lunzhou	Luda	Beijing	Tianjin	Xi-an
H.D.D.	3542	3271	3092	2947	2477

Annual quantity of geothermal energy to be utilized for epace heating:

$$Q = G \times \Delta T \times C \times (H.D.D.) \times B \times 24 \times 1/(t_n - t_w) \quad kJ/yr$$

where

Q=water volume kg/hr;
ΔT-temperature drop utilized in heating °C;
C=heat capacity kJ/kg.°C;
B=correction factor according to stipulations in China: B=0.77-0.87;
t_n=indoor temperature °C;
t_w=outdoor calculating temperature °C;

For making a rough estimate, it is recommended that 20-25% be adopted as the geothermal utilization effi-ciency. To heighten utilization efficiency, it is neceeeary to equip peaking boilere. The capacity of such boilers should be selected from the most suitable designs by comparison. In making estimates, one third of the heat demand ray be ueed as the capacity of the peaking boilers and the utilization efficiency may then be increased by 8%. Thue when peaking boilere are inetalled, the utilization efficiency may be calcu-lated at 28-33%.

Most building6 under conetruction at preeent do not have domeetic hot water euppliee. The gradual instal-lation ehould be taken into coneideration hereafter. The eupply of domestic hot water ie a year-round load, thue the utilization efficiency would be correspond-ingly increased. If a hot water faucet and a shower are inetalled in each household, the utilization effi-ciency may be raised by about 15%.

USABLE TEMPERATURE DROP OF GEOTHERMAL

There is a great difference between the utilization of low temperature geothermal heating and the tradi-tional heating eyetem. In the latter system,the water returns to the boiler after dieeipation of heat in the radiatore. The residual heat is not wasted. In the geothermal heating, however, the residual heat of ueed hot water is generally thrown away. Thue it is neceeeary to equeeze the laet drop of temperature. Still, the degree of temperature drop is governed by the pattern of radiating equipment and technical and economic factore.

Taking for example the frequently used radiators in China, if the temperature of the diecharged water is around 35°C, it is still economically reasonably by eetimation.

When low temperature geothermal water is solely for winter heating through ordinary radiating equipment, there is a limit in the utilization of temperature drop. If it is intended to increaee the utilization up to the neighbourhood of ambient temperature, it is neceeeary to adopt the heat pump eyetem. Owing to the teneion in the supply of electricity in China at preeent and the high coet of electricity, it is difficult to extend the uee of electric heat pumpe. May be it is possible to drive the heat pumps directly by internal combuetion engine8 or eteam turbines and utilize the residual heat from the dispelled eteam. An analyeie on the technical and economic poeeibilitiee ehould be made before the adoption of any euch plane.
In chooeing the plan of utilization, the best total benefit from the sum of initial inveetment plus opra-tion and production costs ehould be taken into consi-deration. Therefore the loweet limit in the utilization of temperature drop might not be the best plan to be chosen. Each object is to be choatn with the actual eituation in view, and then eelect a better and more effective plan.

METHOD OF COMPARISON

1. Conditione for comparieon

Calories of heat rrupply from both sources are iden-tical.

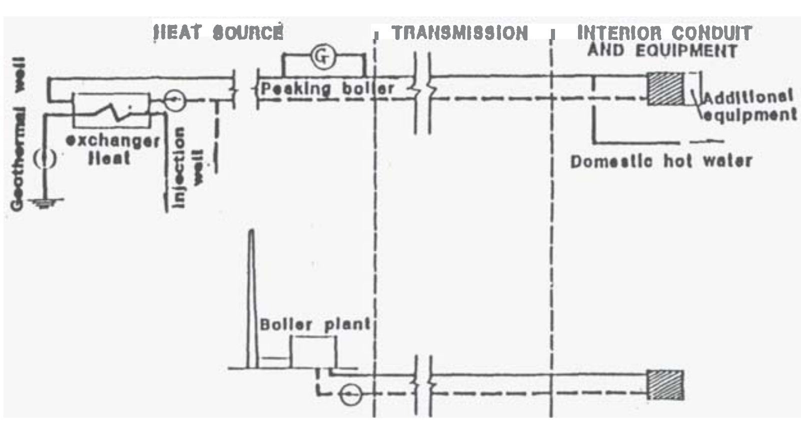

Fig.1 Compare two projects for dietrict heating

With a view to simplifying calculation , identical iteme are neglected in making comparieone of initial inveetmente. It may be seen from Fig. 1 that by diepatching geothermal to the location of the boiler plant a0 part of heat source, the original network of pipe linee and the pipe linee within the buildings are the same; whilet the additional inveetment for eupply of more radiating equipment within the building due to the low temperature of geothermal water is to be considered.

2. Method of calculation

Compare two projects for their initial investments , yearly costs of production and examining the number of yeare required for the inveetment difference.

A LIVING EXAMPLE

1. Ground Conditione

Table 3, Heating Load for Dwelling Areaa

1	Building area with heat eupply	663,000	m^2
2	Outside calculating temperature	-9	°C
3	Indoor temperature	18	°C
4	Peak load in epace heating	194.31	10^6 KJ/hr
5	Number of days in epace heating period	151	day
6	Accumulated degree-hour for space heating	2,233	°C,day
7	Annual load for epace heating	385,680	10^6.KJ/day
8	Annual load for domestic hot water	225,319	10^6.KJ/day

The dwelling area north of the Athletic Institute is in the southwestern part of the Tianjin City. It is adjacent to the Water Park where there are beautiful eurroundinge as well as communication facilities. It is located in the prevailing wind of the city and is an ideal place for dwelling, where new groups of living quartere are being built now. See Fig.2.

2. Heating Supply from Geothermal

At a distance 3-7 km eouth of the dwelling area, there exiete a geothermal anomaly zone with an area of about 11 sq. km where the geothermal gradient is 6°C/100m. According to the opinion of the geological department, the adopted depth of the well le to be 1500m, the length of the pipe linee is to be 8 km, and the geothermal gradient is to be calculated at 5.6°C/100m.

On choice of the utilization project

A better project is to be eelected where the total inveetment and production cost are the loweet. It is aecertained the injection temperature of water eupplied to the radiatore, 76°C; temperature of return water, 36°C; diameter of pipes, 400mm. The varioue expenditures are listed in Table 4.

3. Explanation for making comparieone in the calculations

The initial inveetment includee the following items: boiler plante -- ¥36,000/10^6 KJ • hour; well drilling --¥400/M; titanium plate --¥1300/M^2; tranemieeion pipe --¥500/M; radiators --¥12.5/M^2 floor. The annual production cost consists of coetr for fuel, water, electrical power, wagee , depreciation charge., overhaul

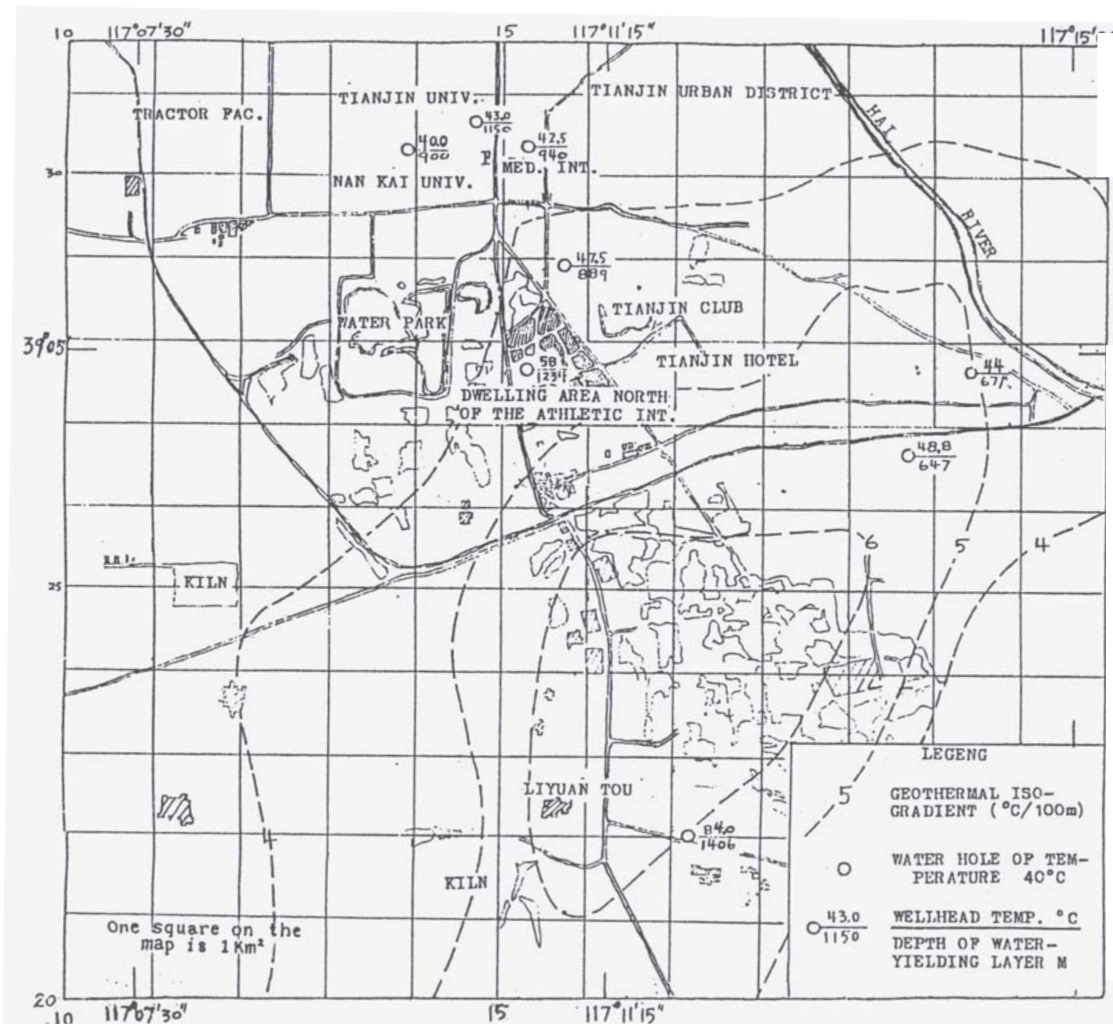

Fig.2

Table 4.. Comparision Between two Heat Supply Projecte

Item		Space Heating		Spaco and Domestic	
		Boiler	Geoth.	Boiler	Geoth.
	Consumption of coal T/yr.	35,430	5,315	58,884	5,315
	Coal saved from geoth. T/yr		30,115		53,569
Initial investment	Boiler plant	7.046	2.355	8.120	2.355
	production and injection well		10.80		10.800
	Heat exchanger and pump station		3.51		4.040
	Tranemissin pipes		7.28	1.090	8.280
	Radiating equipment	7.40	9.61	7.400	9.610
	Total	14.446	33.555	16.610	35.085
	Balabce	19.109		'7.475	
	Annual production coet	2.950	2.047	4.900	3.293
	Balance	.903		1.607	
	Number of years (pay off)		21.2		10.9

and management. The cost of coal in boiler heating conetitutes 70% of the total production coet. The heat value of coal is 16,750KJ/Kg, and its price is ¥50/ton.

Accoding to the calculatione by experts, the gains received in the reduction of air pollution by ueing geothermal energy instead of coal in heating are rather high. But this kind of calculation is not accepted by most of the specialists at preeent.

The compreheneive report on feasibility study ehould deal with resources, economic benefits, and the influence on environment. Failure to satisfy any one of there items will render the study unapplicable. The above analyeie is only the economic aepect.

NEARBY EXPLOITATION

For those geothermal welle from which the average dietance of water tranemieeion doee not exceed 200m, for places where exploitation of geothermal may be obtained from neardy wells, and where are different amounts of yaer for repayment of the difference in capital inveetment, the smallest geothermal is ehown in Fig. 3. In Fig. 3, the continuous indicates the heating without eupplying sanitary hot water.

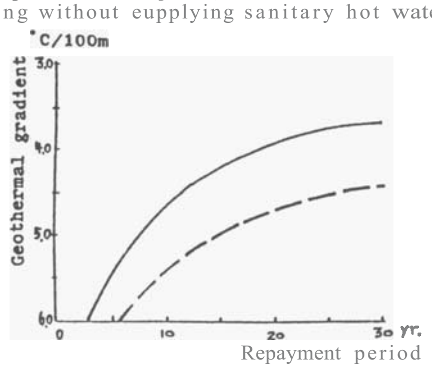

Fig.3 Geothermal gradient-repayment period relation

CONCLUSION

If is required to repay within 15 yeare for the inveetment in geothermal heating bigger than the investment in heating by boiler plante, it is not practicable in dietricte where the geothermal gradient 4°C/100m.

There is quite a big difference in economic benefit as to whether there exists a load for the eupply of domeetic hot water. If there is only a load for epace heating, it is impracticable in districts where the geothermal gradient 4.5°C/100m. .

In dietricte where the geothermal gradient is equal to 4.5°C/100m, the ecomomic benefits from heat eupply by geothermal and from boiler plants are almost identical. Should, however, there be a load for the supply of domeetic hot water as well, the project for use of gerthermal would be more superior than the project of boiler plants.

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