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People's Republic of China: Survey of low-temperature geothermal energy

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PEOPLE'S REPUBLIC OF CHINA: Survey of Low Temperature Geothermal Energy.

Geography.

Area 9,560,985 km^2
Population 852,130,000 (1976)

Information.

The questionnaire was sent to K. Xin because he had visited Iceland in 1979 as a United Nations University (UNU) Special Fellow. A reply was received but Xin was not able to give much information relevant to the survey.

In January 1980 I.B.Fridleifsson visited the People's Republic of China (PRC) on UNU business and was able to gather valuable information for the survey by meeting people working on geothermal energy. Fridleifsson provided data on thermal water use in Tianjin, Beijing, Kunming, Xiang and Xiaotungsan. Several papers were consulted for further information.

Utilization.

Geoheat is used for various purposes in the PRC to-day. Among these are electricity generation (high and low-temperature fluids), space heating of residential and industrial buildings and green-houses, health resorts, various industrial uses (textiles, printing and dyeing, cement production, boilers) and extraction of chemicals. Some use in agriculture has also been reported. For most of these limited information is available on actual energy use.

In the city of Tianjin some 40 x 10^6 m^3/year (1268 l/s) of 30-50°C thermal waters are produced from 190 boreholes for uses in the textile industry and for space heating, baths and other uses. In 150 wells the temperature is 30-40°C and in 40 wells about 50°C. The average depth of these wells is 860m. All the wells have a

down-hole pump. In one borehole drilled 1972 to 786m (152mm diameter) the water level is now at 50m. In most of the 190 boreholes there is a 3-5m draw-down per year. In the one borehole mentioned above the down-hole pump is set at 75m. The pump is 4" with a 34 kW motor and pumps 60m^3/h (17 l/s) of 50°C water. There are 4 textile factories in Tianjin that use thermal water amounting to 6000 m^3/day (69 l/s) in total. The thermal water is used down to 20-30°C. The thermal power of the thermal waters used in Tianjin can be estimated by assuming that the average flowrate of the 40 boreholes producing 50°C water and 150 boreholes producing 30-40°C is the same. It has also to be assumed that the average temperature of the 150 boreholes is 35°C. It follews that 267 l/s of 50°C water and 1001 l/s of 35°C water amount to 11.2 MW, 112.9 MW and 202.6 MW for 40°C, 15°C and 0°C reference temperature respectively.

In the city of Beijing (population 8 millions) there have been drilled 20 wells of which 14 are used. The deepest well is 2600m, the average depth is 1000m. Most of these wells need pumping. Maximum water temperature 69°C lowest 45°C with 50°C as average. Water level at 40m. Extreme flowrate values are 700-1500 m^3/day with 1000 m^3/day (12 l/s) as average from the 14 producing boreholes. The thermal water in Beijing is used in the textile industry, for space heating and baths. In the future it is hoped that 10% of Beijing will be heated by geothermal water. Assuming 14 boreholes that produce 12 l/s each (168 kg/s in total) of 50°C water the thermal power becomes 7.0 MW, 24.6 MW and 35.2 MW at 40°C, 15°C and 0°C reference temperatures respectively.

In the city of Kunming there are 3 wells used for baths producing in total 1200 m^3/day (14 l/s) of 55°C water. This gives 3.2 MW, 2.3 MW and 0.9MW thermal at 0°C, 15°C and 40°C.

In the city of Xian there are used 400 m^3/day (4.6 l/s) of 42°C water for industrial purposes. This corresponds to 0.8 MW, 0.5 MW at 0°C and 15°C respectively.

There are about 80 health resorts (sanatorium) in the PRC that use geothermal water (Cai 1979). One of these is at Xiaotungsan about 40 km from Beijing. The thermal water there is used for both baths and space heating. There are two wells 76m and 120m producing 2600 m^3/day (30 l/s) of 54°C water by pumping. Artesian flow is only 1200 m^3/day. The heated area is 25,500 m^2. A 800m pipeline serves the sanatorium. The associated thermal power amounts to 6.8 MW, 4.9 MW and 1.8 MW for 0°C, 15°C and 40°C respectively.

It is reported (Cai 1979, An & Huang 1980) that low-temperature geothermal waters are used for industrial and space heating purposes in other cities, but no data is yet available on flowrates and temperatures to estimate the associated thermal power. The largest users of thermal waters are therefore probably Tianjin and Beijing.

Cai (1979) gives details about 7 experimental electric power generation stations in the PRC. While it is not clear if these are located in high or low-temperature fields, the stations use waters at low temperatures. Table 1 is reproduced from the paper by Cai (1979). Fan (1979) and An & Huang (1980) have given information about several geothermal fields in the PRC. For the present survey it is assumed that high-temperature areas (with measured temperature above 180°C) in the PRC are only to be found in the Xizang-Yunnan Geothermal Zone (and Taiwan Geothermal Zone). The Yangbajing geothermal field in Xizang is probably a high-temperature field and will therefore be excluded from this survey (the silica temperature has been reported 250°C). Table 1 shows that there is a 1 MW-electrical power station there using steam/water at 150°C. Apparently there are two 3 MW-electrical power stations under construction in the Yangbajing field and will probably be operational 1980 and 1981. The other stations (using waters at 67-92°C) have a total design capacity of 0.936 MW-electrical (about 1 MW-electrical). Cai (1979) gives details about the 50 kW-electrical experimental binary plant at Wentang (Yichun in Jiangxi). One artesian well produces 100 m^3/h of 67°C water. This fluid is

used in the binary plant and then in local greenhouses, sanatorium, hospital and rice paddies to raise the soil temperature. This full use of the thermal water amounts to 7.9 MW, 6.1 MW and 3.2 MW at 0°C, 15°C and 40°C reference temperatures. Table 1 shows that of the 7 experimental power stations in the PRC there are 3 using flashed steam and 4 some binary fluid. Unfortunately there is no technical information available on the flowrates (and temperatures) to enable an estimation of the thermal opwer involved, except the 50 kW plant at Yichung. The 0.886 MW-electrical (0.936-0.050) capacity in the low-temperature fields will therefore have to be omitted for the time being.

Table 2 shows the known low-temperature geothermal energy utilization in the PRC. As already stated Table 2 does not show the thermal power associated with 886 kW-electrical generating capacity in the low-temperature fields because no information is available. While there are about 80 hot spring savatoriums in the PRC (Cai 1979) there are 8 main locations (Finn 1979) with active operations. Two of these are in Tianjin and Beijing, one at Xiaotungsan and one at Yichun. In view of the above and other factors it could be argued that Table 2 shows approximately 1/2 the low-temperature geothermal energy used in the PRC at present. However, until more data becomes available the values in Table 2 shows our best information.

An & Huang (1980) give details about the Dengwu field, Fengshun country, Guangdon province. Information supplied by I.B. Fridleifsson indicates that tens of boreholes have been drilled with maximum flowrate 3000 m^3/day but average flowrate 1000 m^3/day at temperatures 93°C. As shown by Cai (1979) some of this water is used for electric power production. Some of the thermal waters are reported being used in agriculture (fish hatching, farming). The information given to I.B. Fridleifsson indicates that the two experimental power stations use 300 m^3/day (3.5 l/s) of 93°C water, the discharge temperature being 60°C. The discharge temperature for the agricultural operations was reported as 30°C .

Exploration/Assessment.

During the period 1960-1970 the development of geothermal resources in the PRC was limited to hot springs for therapeutic purposes (Cai 1979). Since 1970 however the emphasis has shifted to the comprehensive use for industry and agriculture. To-day more than 2/3 of the provinces, municipalities and autonomous regions have started reconnaissance surveys and exploration work for utilizing geothermal resources. An & Huang (1980) stated that "since 1970 geothermal work has developed rapidly and at present geothermal resources have found their utilization in power generating, extraction of chemicals, textiles, printing and dyeing, space heating, greenhouses, medical treatment, etc."

Both Cai (1979) and An & Huang (1980) give information about the geothermal resources of the PRC. The An & Huang (1980) information will be used here for illustration. There are about 2500 geothermal water points in the PRC. In the north all water points above 20°C are included but 25°C is the temperature used in the south. There are 4 major geothermal zones in the country: Xizang-Yunnan Zone, Taiwan Zone, Eastern Coastal Zone and North-South Zone. The major features of these zones are explained. It appears that high-temperature fields (with measured temperature above 180°C) are to be found in the Xizang-Yunnan Zone and the Taiwan Zone. There are identified 3 types of resources in the PRC,

I) magmatic activity type;
II) uplift-fault type and
III) depressional basin type.

An & Huang (1980) demonstrate these 3 types by considering the Yangbajin, Dengwu and Beijing geothermal fields, respectively. In the Xizang-Yunnan Zone there are more than 400 hot water points, 145°C maximum measured temperature. In the Taiwan Zone 103 hydro-thermal areas, 294°C maximum temperature measured. In the Eastern Coastal Zone more than 550 known hot water points, 63°C maximum temperature. In the North-South Zone about 100 hot water points, 92°C maximum measured temperature. It is of interest to note that An & Huang (1980) classify geothermal energy as following: 25-40°C

low temperature, 40-60°C medium temperature, 60-100°C high temperature and above 100°C super-heated.

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TABLE 1

Experimental geothermal power stations in the PRC (Cai 1979)

Name of Experimental Geothermal Power Station	Location	Thermal Water Temperature (°C)	Design Capacity (kw)	System Type	Working Medium	Generating Date
Fengshun	Fengshun (Dengwu), Guangdong					
No. 1 Unit		91	86	Flashed-steam cycle	Water	1970. 10
NO. 2 Unit		91	200	Dual Fluid cycle (Binary cycle)	Isobutane	1971. 9
Wentang	Yichun (Wentang), Jiangxi	67	50	"	Chlorethane	1971. 9
Huailai	Huailai (Houduyao), Hebei	85	200	"	Chlorethane, Normal butane	1971. 9
Huitang	Ningxiang (Huitang), Hunan	92	300	Flashed-steam cycle	Water	1975. 10
Yingkou	Xiongyue Liaoning	75-84	100	Dual Fluid cycle (Binary cycle)	Normal butane Freon	1977. 4
Yangbajing	Yangbajing, Xizang	150	1000	Flashed-steam cycle	Water	1977. 9

TABLE 2

Known uses of low-temperature geothermal energy in the PRC

Location	Thermal power MW		
	>0°C	>15°C	>40°C
Tianjin	202.6	112.9	11.2
Beijing	35.2	24.6	7.0
Yichun*	7.9	6.1	3.2
Xiaotungsan	6.8	4.9	1.8
Kunming	3.2	2.3	0.9
Xian	0.8	0.5	0.0
Total	256.8	151.3	24.1

* Includes 50 kW-electrical of a total of 936 kW-electrical generating capacity in low-temperature fields that are however excluded here because no further information is available.