NOTICE CONCERNING COPYRIGHT RESTRICTIONS

AN ESTIMATE OF EXTRACTABLE HEAT FROM HOT SPRING WELLS FOR DIRECT USES OF GEOTHERMAL ENERGY IN BIG SPAS IN JAPAN

Mitsuru Sekioka

Department of Geoscience, National Defense Academy
Yokosuka, Kanagawa 239, Japan

Abstract

It is attempted to estimate extractable heat from only existing hot spring wells in big spas in Japan, under the presumption that no geothermal well is newly drilled. Since the Japanese enjoy the pleasures of natural baths, direct uses of geothermal energy in Japan are required to coexist with bathing. To extract efficiently heat from existing hot spring wells, 120 big spas are selected from 2360 ones, under the standard that whole wells at a spa have heat discharge over 5 Gcal/hr at a flow rate of 2000 l/min and over. Then, by assuming that the temperature range of hot water between 35°C and 50°C is put on allocation for bathing and the disposal temperature of the water is 15°C, the total extractable heat from the 5676 hot spring wells for direct uses in those spas is estimated at 1512.32 MWt in coexistence with bathing.

INTRODUCTION

In Japan, geothermal energy is used for direct uses at a number of sites as well as for power generation (283.8 MWe). So far Sekioka and his colleagues have reported several aspects of the direct uses of geothermal energy in Japan (Sekioka et al. 1979; Sekioka and Fujitomi 1981; Sekioka 1984, 1986, 1989, 1990 and 1992) at the GRC annual meeting.

Japan is blessed with many hot springs, which are possible sources for direct uses of geothermal energy, because their temperature is too low to generate electric power. But unfortunately, since the Japanese have enjoyed unbelievably the pleasures of natural baths, hot spring water is frequently supplied to hotels in spas for bathing. Geothermal direct uses are, therefore, required to coexist with natural bathing. For that purpose, the temperature range from 50°C to 35°C of hot spring water must be considered to allocate for bathing in the following computation.

In order to assess a potential heat source for direct uses in Japan, the previous paper (Sekioka, 1990) was devoted to compute extractable heat from all hot spring wells distributed all over the country, except those temperature range. The total extractable heat of 2697.46 MWt was obtained based on the data from the Geological Survey of Japan (Sumi, 1975). The data used there were rather old,

but recently the new data of hot spring wells were published by the New Energy Foundation (NEF, 1993). Since the NEF aims to promote direct uses of geothermal energy in large scale, the data are limited to those in big spas with heat discharge over 5 Gcal/hr at a flow rate of 2000 l/min. The NEF selected the data of 5676 wells in 120 big spas from 22,353 wells of 2360 spas in whole Japan. There are two advantages in utilization of the data as follows; 1) Of course, this is the newest data of hot springs in Japan. 2) Since, in general, the big spas have many sojourner in addition to the large population, disqualifying factors such as long distance between hot springs and direct use sites having large heat density may be reduced.

In the present paper, by the use of this new data, it is attempted to provide a new version of extractable heat from hot spring wells in big spas.

ASSUMPTION AND COMPUTATION

The extractable heat is computed from existing hot spring wells under the following assumptions, placing emphasis on coexistence with natural bathing (Fig.1).

Firstly, the water with temperature of 55°C and over is usable for direct uses down to 50°C, before delivering it into bathing and is also usable between 35°C and 15°C by filtering it after discharge from bathing.

Secondly, the water with temperature above 40°C to less than 55°C is usable for direct uses between 35°C and 15°C by filtering it after discarge from bathing.

Thirdly, the water with temperature above 25°C to less than 40°C is usable only for direct uses, as is, down to 15°C, because of its inadequacy for bathing.

In the aforementioned conditions the final temperature of the usable hot water is assumed to be 15°C, an average air temperature in Japan.

Several examples of those allocation were illustrated by Sekioka (1990). The result of computation shown in Table 1 for the 8 districts in Japan (Fig.2) indicates that the extractable

heat reaches 1512.32 MWt. The extractable heat from the higher temperature water alone occupies the first place contributing 36% of the total, but the heat from the filtered low temperature water is collectively 851.65 MWt, which contributes 56%. Heat pumps may be frequently useful tool for the waste water.

More abundant utilization of this large quantity of filtered waste water after bathing for direct uses can consume fully the heat of discharged hot water to prevent thermal contamination of rivers and lakes.

COMPARISON OF EXTRACTABLE HEAT WITH PRESENT IN-STALLED THERMAL POWER

Comparison of the extractable heat with the in-stalled thermal power of 179.75 MWt as of April of 1992 (Sekioka, 1992) in the 8 districts reveals that the former is nearly 10% or so of the latter, with 12% on total (see the last column in Table 1). This means that, exerting no effort to develop further resources, at present Japan has a large surplus of potential installed thermal power for direct uses of geothermal energy.

On the other hand, the thermal energy used as of April of 1992 is 106.27 MWt which has the total average load factor of 59% (Sekioka, 1992). When the extractable heat of 1512.32 MWt is multiplied by 59% of the total average load factor, the thermal energy used may be expected as about 900 MWt. If 1.15×10^3 kl/yr of fuel oil is converted to 1 MWt of geothermal energy, under the assumptions that heat generated by combustion of fuel oil is 8570 kcal/l and the efficiency of the boilers is 0.75, 221.4×10^6 kl/yr of fuel oil sales volume in 1991 in Japan (MITI, 1991) is equivalent to 1.9×10^5 MWt of geothermal energy. This means that the oil saved by geothermal direct uses will rise from 0.06% at present up to 0.47%.

CONCLUSION

Extrctable heat from the 5676 existing hot spring wells in the 120 big spas is computed without drilling of new geothermal wells, under the condi- tions provideing no influence on natural bathing. The heat is 1512.32 MWt, which is about 8.4 times larger than the present installed thermal power of geothermal energy of 179.75 MWt in Japan. If the total average load factor of 59% is adopted, the thermal energy used may be expected to increase from 106.27 MWt at present up to about 900 MWt. This can also raise the amount of oil saved by geothermal direct uses from 0.06% to 0.47%.

REFERENCES

Ministry of International Trade and Industry, 1991. Yearbook of production, supply and demand of petroleum, coal and coke. 202-203.

New Energy Foundation, 1993. Report of the fundamental investigation on introduction of geothermal water. (in Japanese)

Sekioka,M., 1984. A summary of direct utilization of geothermal energy in Japan. GRC TRANSACTIONS 8, 163-167.

Sekioka,M., 1986. An analysis of direct uses of geothermal energy in Japan. ibid., 10, 39-42.

Sekioka,M., 1989. An analysis of direct uses of geothermal energy in Japan with respect to inlet temperature and flow rate. ibid., 13, 63-68.

Sekioka,M., 1990. Potential installed thermal power from direct use of geothermal energy in Japan. ibid., 14, 177-181.

Sekioka,M., 1992. The present state of geothermal direct-use in Japan -1992-. ibid., 16, 25-27.

Sekioka,M., M.Sato and M.Ishihara, 1979. Geothermal snow melting system in Japan. ibid., 3, 639-642.

Sekioka,M. and M.Fujitomi, 1981. National projects on direct utilization of geothermal resources in Japan. ibid., 5, 567-569.

Sumi,K., 1975. Catalogue of hot springs and mineral springs in Japan, Geological Survey of Japan. 134pp.

Table 1. Extractable heat from existing thermal spring wells
classified by wellhead temperatures. (MWt)

| Region	Wellhead temperature (T)				Instal-led thermal power in April 1992	Rate of uti-liza-tion %
	T ≥ 55C	55C > T ≥ 40C	40C > T ≥ 15C	Total		
	Usable temperature range					
	≥ 50C	35-15C	35-15C	≥ 15C		
Hokkaido	78.33	76.01	88.00	27.86	270.20	38.39	14
Tohoku	65.26	57.56	54.37	16.05	193.24	21.76	12
Kanto	30.37	29.89	34.14	8.51	102.91	6.83	7
Chubu	172.47	130.16	73.23	38.51	414.37	28.20	7
Kinki	7.11	12.11	6.71	0	25.93	0.26	1
Chugoku	12.72	4.97	2.78	4.05	24.52	0.70	3
Shikoku	0	0	1.81	0	1.81	0	0
Kyushu	174.94	158.09	121.82	24.49	479.34	83.61	17
Total	541.20	468.79	382.86	119.47	1512.32	179.75	12
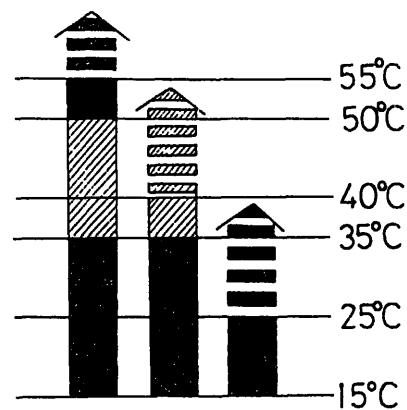
Figure 1. Temperature ranges for extractable heat from thermal spring water at different wellhead temperatures for direct uses in coexistence with bathing. Dark parts indicate the extractable range for direct uses and shadowed parts the range for bathing.
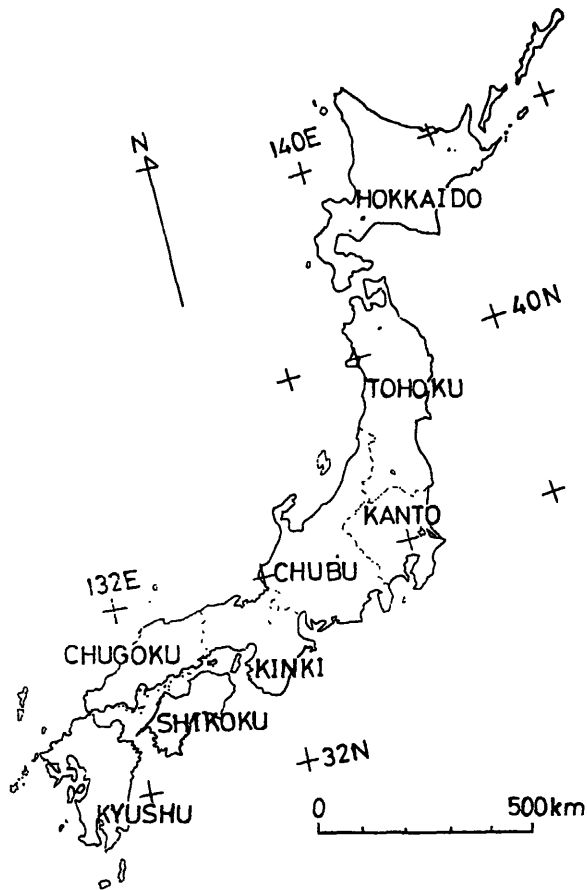
Figure 2. Map of Japan showing her eight districts.