A STUDY FOR THE USE OF LOW ENTHALPY GEOTHERMAL WATER FOR DISTRICT HEATING

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Low enthalpy geothermal water in Japan was deposited in generally new sedimental basins (Tertiary and Quaternary). Such basins are found widely, in plains and mountain areas.

In particular, many low enthalpy geothermal water resources are in Northern Japan, where the winter climate is very cold. Therefore, the said low enthalpy geothermal water resources are anticipated to be attractive sources of energy, though, so far, they have not been utilized much.

The said resources generally exist in layers at over 1,000m depth. To use these resources, we have to drill geothermal wells, of which the depth may be between 1,000m to 2,000m, and the drilling costs are estimated at several tens of millions of yen to 2 hundred million yen. Therefore, the district heating will have to be on a large scale so as to utilize an effective system and with a stable heat demand over the long term, because in the case of a smaller scale system an economical system will be unobtainable.

Hereunder, are five case studies carried out for low enthalpy geothermal district heating systems regarding the Sapporo City area in Hokkaido. The construction cost and working expenses in these five case studies are estimated as follows:

1. Presuppositions

(a) Climate of Sapporo City: Table 1

Table 1 Average Temperature of Sapporo City (°C) (1941-1970)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
-5.1	-4.4	-0.6	6.1	11.8	15.7	20.0	21.7	16.9	10.4	3.7	2.8	7.8

(b) Object: New town, Area: 3.3×10^4 m^2
Total building area 62,500 m^2, (Offices 15,600 m^2, Shops 35,400 m^2, Apartment buildings 10,500 m2 - 150 dwellings). The scale of Case 1 is half that of the other four case studies.

(c) Heat consumption: Average consumption of heating in January 40 Kcal/m2 h x 62,500 m2 = 2,500 Mcal/h (Figure 1)
Peak consumption of heating in January, 56 Kcal/m^2 h x 62,500 m^2 = 3,500 Mcal/h

(d) Annual heat consumption: 11,553 Gcal/year

(e) Geothermal well:
 (1) Production well: 180ø x 1,600m, water temperature; 53°C, Production; 60 t/h, water quality; salty
 (2) Reinjection well: 180ø x 1,600m.

(f) Rate of interest: 6%

(g) Depreciation years: 15 years

(h) Electric charges: 20 yen/KW h

(i) Fuel cost: Kerosene 40 yen/liter

(j) Land costs not included in this estimate.

2. Five case studies

Case 1: Geothermal Water only
 (1) Energy source: geothermal water of 53°C, (2) Heat exchange system (Utilize ΔT=30°C, 53°-33°C, used geothermal water is reinjected to well), (3) Heat supply ability: Half that as compared with the other four case studies (1,300 Mcal/h).

Case 2: Geothermal Water only
 (1) Energy source: geothermal water of 53°C, (2) Heat exchange system: same as Case 1, (3) Heat supply ability: Twice compared with that of Case 1 (2,600 Mcal/h).

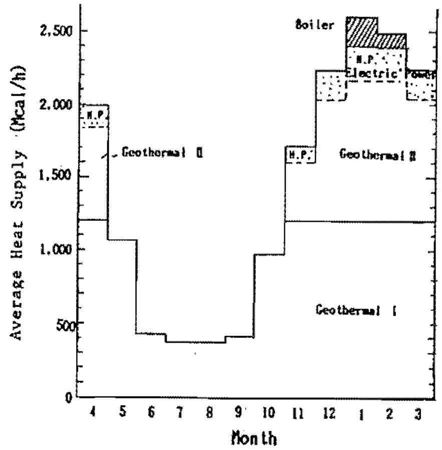

Fig.1 Amount of Heat Supply (Case3)

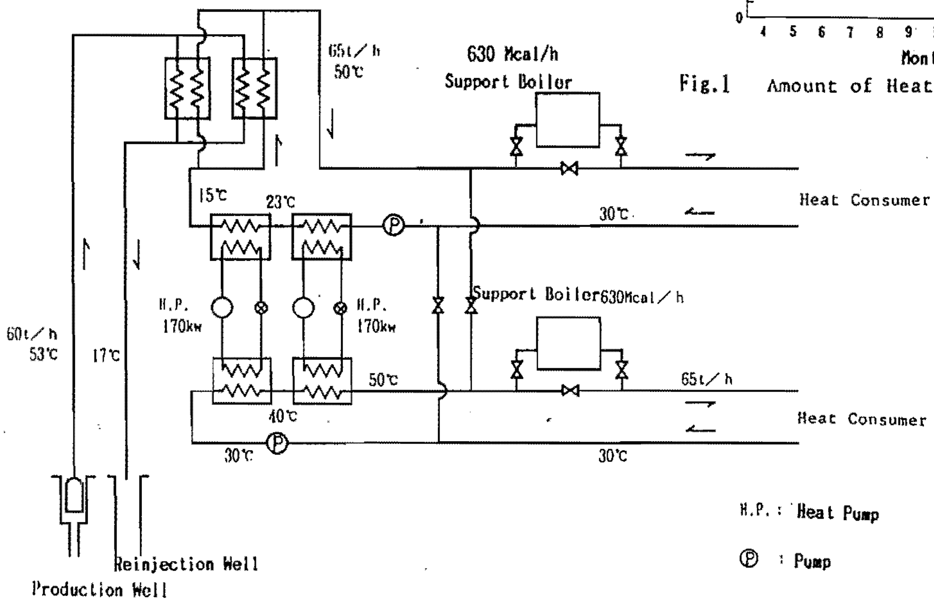

Fig.2 Geothermal and Heat Pump System(Case3)

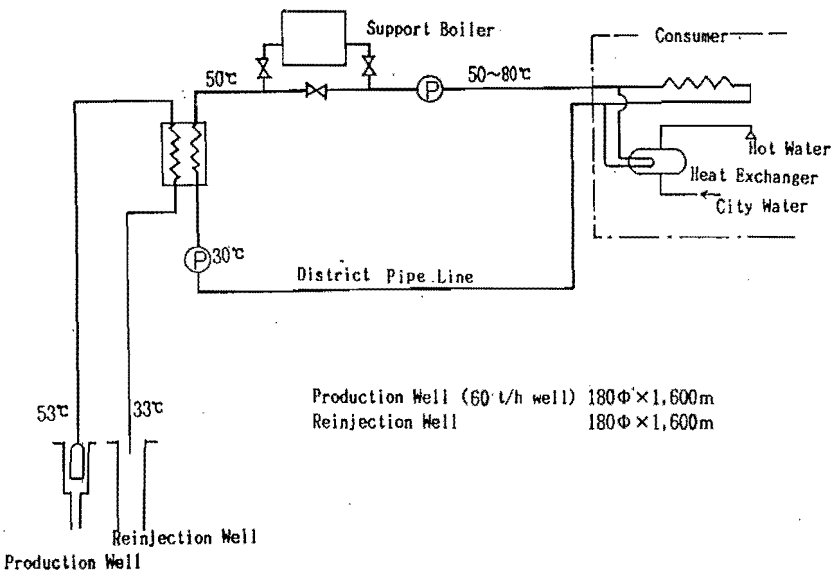

Fig.3 Geothermal and Boiler System(Case4)

Case 3: Geothermal Water.Heat Pump.Boiler System: (Fig. 1 and Fig. 2)
(1) Energy source: geothermal water of 53°C, electric power, kerosene, (2) Heat exchange (Utilize $\Delta T=36°C$, 53°C-17°C, used geothermal water is reinjected to well), (3) Heat supply ability: 2,600 Mcal/h.

Case 4: Geothermal Water and Boiler System: (Fig. 3)
(1) Energy source: geothermal water of 53°C, kerosene, (2) Heat exchange (Utilize $\Delta T=30°C$, 53°C-33°C), (3) The heat supply ability: 2,600 Mcal/h.

Case 5: Geothermal Water.Gas Engine Generator and Gas Boiler System:
(1) Energy source: geothermal water of 53°C, Methane gas 60 Nm3/h (gas with geothermal water) - this gas used for gas engine generator to produce electricity and uses Gas Boiler), (3) Heat supply ability: 2,600 Mcal/h.

Table 2 The Trial Estimate of District Heating by Using Low Enthalphy Geothermal Water (53°C) (Construction Cost, Working Expenses and Heat Cost)

(Thousand Yen)

	Case 1	Case 2	Case 3	Case 4	Case 5
Heating System	Geothermal Water only	Geothermal Water only	Geothermal Water+Heat Pump+Boiler	Geothermal Water+Boiler	Geothermal Water+Gas -Engine Gene. +Gas Boiler
Heat Supply Total Building Area (be equal dwellings)	31,250m^2 (445)	62,500m^2 (890)	62,500m^2 (890)	62,500m^2 (890)	62,500m^2 (890)
Annual Heat Load (Gcal/year)	5,777Gcal/yr	11,553	11,553	11,553	11,553
Construction Cost					
Production well & Reinjection well (Well numbers)	172,000 (2 wells)	344,000 (4 wells)	172,000 (2 wells)	172,000 (2 wells)	172,000 (2 wells)
Heat sources equipments	57,320	78,280	145,440	100,940	146,940
Distributing pipe line, etc. (Km)	86,200 (2.4 Km)	147,200 (3.8 Km)	147,200 (3.8 Km)	147,200 (3.8 Km)	147,200 (3.8 Km)
Expenditure (includes design fee,etc.)	60,080	104,520	89,360	79,860	86,260
Starting expenses	75,100	135,000	111,000	100,000	110,600
Total Cost	450,700	809,000	665,000	600,000	663,000
Running Expenses					
Fixed expenses (principal & interest)	37,670	67,630	55,590	50,160	55,430
Personnel expenses	20,000	20,000	25,000	25,000	25,000
Electric costs	5,000	10,000	29,328	9,900	1,000
Fuel cost (Oil or Gas)	0	0	923	26,167	18,780
Others (Repair, management, etc.)	21,150	35,160	35,081	33,843	32,830
Total	83,870	132,790	145,990	145,070	133,040
Heat cost (Yen/Mcal)	14.5	11.5	12.6	12.6	11.5

3. Considerations

(1) The temperature of hot water district heating plants in Japan normally ranges from 80°C to 210°C. But in the case of low enthalphy geothermal district heating, the resource water should be used at a lower temperatures of 53°-30°C, in order to gain effectively heat energy from the water. For this purpose, we should design the consummer's heat installation to be able to use circulating hot water below 30°C, and return this water to the return pipes.

(2) The method to be used should be via use of a thermostatic control valve which prevents the return of water to the return mains until it has given up its useful heat to a lower limit of 30°C.
It is such district heating control valves that make it possible to have the desired temperature differential circulated to the minimum. Return temperature limiting valves are thus one key to one of the biggest savings in capital and operating costs of district heating. These construction costs are comparatively high for using geothermal energy effectively.

(3) Consumer's equipment such as heating panels, radiators, and convectors will be larger than ordinary district heating systems, therefore, I recommend floor heating panels, because these heating systems can be worked by low temperature hot water such as at 30°C.

(4) According to Table 2, I think that the best system is Case 4, as it has the lowest construction cost of the 4 cases, and its running costs are reasonable. Its heat cost is estimated at 12.6 Yen/Mcal, which is at same level of ordinary district heating costs in Hokkaido. Case 2 has a support boiler that can be used at peak load times for back up.

(5) Case 1 and Case 2 are Geothermal water (only) systems, of which geothermal well cost rate per construction cost are higher than the others. They have higher risks as regards drilling wells than the other systems. But in Case 2, its well supply scale becomes larger than Case 1, its working expenses comparatively decrease. The heat cost of Case 2 is estimated at 11.5 Yen/Mcal.

(6) Case 3 suggests that using heat pumps are effective with geothermal water down to a temperature of 17°C. But this system needs much electricity for power, then the heat cost becomes 12.6 Yen/Mcal.

(7) Case 5 has gas accompanying the geothermal water, such as in Naganuma town in Hokkaido. The Gas is almost all methane which is separated from the geothermal water, and it is used for a gas engine generator and support boilers.

(8) From these studies, the possibility of low enthalphy geothermal district heating may be thought of as high, if research into these geothermal resources in inhabited areas is carried out in Northern Japan, and if we develop the technique of heating by low temperature water.

(9) These district heating installations could reduce fire risk and save fossil fuel and would be useful for reducing air pollution in towns.