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Japan: Survey of low temperature geothermal energy

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JAPAN: Survey of Low-Temperature Geothermal Energy

Geography

Area 369,699 km^2

Population 113,086,000 (1976)

Information

The questionnaire was sent to I. Takashima who sent a comprehensive reply. Several papers were consulted for further information.

Utilization

There are both high and low-temperature fields in Japan and both electrical and direct uses. Presently there are six geothermal power stations with installed capacity of 168 MW-electrical. The direct uses are mainly in low-temperature areas, but also at high-temperature areas.

Takashima gave a summary of "present nonelectrical applications of geothermal energy in Japan". In the present survey direct uses in low-temperature areas are to be considered. Takashima showed direct uses at Otake, Matsukawa and Onuma (all high-temperature areas) seperately as 1.5×10^{12} J/day (reference temperature 15°C) in total. All other direct uses (preseumable all at low-temperature areas) were given as 3.866×10^{14} J/day (reference temperature 15°C) which corresponds to 4475 MW-thermal. Takashima stated that "almost all of hot water are directly used for baths and space heating" and also various use (mainly for mineral baths)". It must be assumed that these 4475 MW-thermal are all the thermal waters used in Japan. Takashima stated that 7 main localities use in total 158,176 l/min (2636 l/s) of thermal waters at 56-100 °C but the rest was used at various other localities at 1624 places. Details about direct uses in high-temperature areas (according to Takashima 1.5×10^{12} J/day or 17.4 MW-thermal above 15°C) are given by Minohara & Sekioka (1980).

It was reported by Mashiko & Hirano (1970) that in 1968 "there were 17,126 hot water wells in Japan, 3363 wells of which were no longer used and 1955 wells not get utilized". They stated that: "At present, in the 11,608 wells that are in use, 60% of them have high enthalpy involving vapor and gas with high temperatures above boiling point, and 13% are cool mineral springs that are under 25 °C. There are 2235 wells that are between 25 and 42°C and 8350 wells are above 42°C and not aqueous vapor wells. The total quantity of hot water pumped up from these hot water wells has reached 1,207,194 liters per minute". This flowrate amounts to 20,120 l/s. According to the Japan Geothermal Energy Assocation (1974): "The total discharge of thermal water throughout Japan was about 730,000 l/min (12,167 l/s) in 1966. By 1969 this volume had doubled to 1,330,000 l/min (22,167 l/s). The number of hot springs and thermal water wells had increased to 14,000 by 1969. 70% of these springs and wells produced waters having temperatures above 42°C.... The geothermal energy being discharged as thermal water is approximately 1.5×10^{24} erg/year", (1.5×10^{17} J/year = 4756 MW). This value is close to the one given by Takashima above. Komagata et. al. (1970) report the status of geothermal utilization in Japan.

It was stated above (according to Takashima) that the total thermal power associated with the utilization of low-temperature geothermal energy in Japan amounts to 4475 MW-thermal above reference temperature 15°C. Most of this geothermal energy is used in baths. Takashima gave information on the use of thermal waters in agriculture. These include 4 locations (Ibusuki, Higashi-Izu, Mori-cho and Shikabe) with 43,000 m^2, 1056 m^2, 19,000 m^2 and 1880 m^2 of greenhouses, 64,936 m^2 in total. The flowrate and inlet temperature for 3 of these was given. To estimate the thermal energy associate with the 19,000 m^2 at Mori-cho, it was assumed to be the same as at Ibusuki (43,000 m^2) or 86 W/m^2, 147 W/m^2 and 184 W/m^2 for 40°C, 15°C and 0°C reference temperature respectively. The total thermal power associated with the 64,936 m^2 (65,000 m^2) was 10.3 MW, for 16.8 MW and 20.7 MW for 40°C, 15°C and 0°C respectively. Takashima reported that geothermal energy was used at Minami-Izu (300 l/min at 115°C) and Beppu-Ueda (small use) for animal husbandry. At Atagawa (2000 l/min at 105°C) thermal waters are used for breeding alligators and crocodiles and at Shikabe (70 l/min at 70°C) eel and carp breeding are carried out with the use of geothermal energy. The total thermal power associated with these

animal husbandry operations amounts to 10.9 MW, 14.9 MW and 17.4 MW for 40°, 15°C and 0°C respectively. Takashima reported that 14,267 m^2 of roads etc. are heated with geothermal energy for snow-melting. This energy/used for space heating. Sekioka et.al. (1979) report on these snow melting operations in detail. Takashima reports space heating systems (space and water heating, mineral baths) at 9 locations using 12,386 l/min (206 l/s) of thermal water at 25-70°C. The space heating systems at Otake, Matsukawa adn Onuma are excluded here since they are in high-temperature fields. The air conditioning system at Beppu-Kankaiji is also omitted here for the same reason? The thermal power associated with the 9 space heating systems using low-temperature fluids (fields) as reported by Takashima amount to 23.0 MW, 49.1 MW and 65.0 MW for 40°C, 15°C and 0°C reference temperature. Table 1 shows the utilization of low-temperature geothermal energy in Japan for space heating greenhouses and animal husbandry. These uses represent less than 2% of the total utilization (4475 MW-thermal above 15°C).

use was reported as part of energy and Sato & Sekioka

TABLE 1

Utilization of low-temperature geothermal energy in Japan[x]

Use	Thermal power MW		
	>0°C	>15°C	>40°C
Space & water heating	65.0	49.1	23.0
Greenhouses	20.7	16.8	10.3
Animal husbandry	17.4	14.9	10.9
Total	103.1	80.8	44.2

x Not including bathing, since total utilization amonts to 4475 MW-thermal (>15°C).

Takashima gave information on "past and future utilization" as follows: "There are no big changes for the use of low-temperature geothermal energy related to volcanic activity from early 1970's to present and don't expected to have a big change in the future. However, Japanese government want to develop the non-volcanic geothermal resources of deep sedimentary basin and use them for space heating and binary systems etc. in the amount of 2.5×10^5 kl in 1985, 5.4×10^6 kl in 1990 and 2.1×10^7 kl in 1995 (oil equivalent) respectively". The unit kl is probably kilolitre (1000 litres).

Exploration

Takashima stated that most exploration projects of low-temperature resources are done by commercial companies on a very small scale. He also stated that only one large scale project was under way at present - in the deep sedimentary Wada Basin (Akita prefacture). However, it is evident from papers by Sumi (1978) and Nakamura et.al. (1978) that the Geological Survey of Japan does extensive geothermal exploration work - albeit mostly in high-temperature fields.

Assessment

Takashima sent a table showing: "Assessment of non-volcanic geothermal resources or deep sedimentary basin in Japan" and stated it was a "preliminary assessment". The table lists 30 localities. The total area of 25 of these is 39,372 km^2 and the "recoverable heat of... 22 localities (is) 2.0 x 10^{17} kcal" above 15°C reference temperature. The corresponding recoverable volume of geothermal fluid is 2610 x 10^9 m^3. (2 x 10^{17} kcal = 8,4 x 10^{20} J). It was also stated by Takashima that: "We don't have a national wide resource assessment of low-temperature geothermal resources related to volcanic activity(We already use fairly large amount of this kind of resource)". Sumi (1978) gives an excellent overview of the geothermal resources of Japan. Geothermal assessments have beeen carried out in 1957, 1970, 1974 and 1976. The main emphasis of all of these assessments has been on high-temperature fields for power generation. It is of interest that the natural heat discharge from 10,578 hot springs and fumaroles (presumably in both high and low-temperature fields) in Japan has been reported (Sumi 1978) as 16 x 10^{10} cal/min (11,200 MW-thermal). The reference temperature was not given. The above value was calculated (Sumi 1978) by simple preportional multiplication using the observed value in Hokkaido where 6.3 x 10^{10} cal/min is discharging from 411 hot springs.

Bibliography

Komagata, S., Iga , H., Nakamura, H. & Minohara Y., 1970: The Status of Geothermal Utilization in Japan. Pisa, 185-196.

Mashiko, Y. & Hirano, Y., 1970: New Supply Systems of Thermal Waters to a Wide Area in Japan. Pisa, 1592-1595.

Japan Geothermal Energy Association, 1974: Geothermal Energy Utilization in Japan. 45 p.

Hirakawa, S., 1978: Situation of Geothermal Resources in Japanese Primary Energy. Journal Japan Geothermal Energy Association, 15, 7-10.

Sumi, K., 1978: Geothermal Resources of Japan. Energy Developments in Japan, 1, 3-32.

Nakamura, H., Sumi, K. & Ozawa, T., 1978: Geological and Geochemical Characteristics of Geothermal Resources in Japan. Energy Developments in Japan, 1, 277-301.

Sato, M. & Sekioka, M., 1979: Geothermal Snow Melting at Sapporo, Japan. Geo-Heat Utilization Center Quarterly Bulletin, 4 (3), 16-18.

Sekioka, M., Sato, M. & Ishihara, M., 1979: Geothermal Snow Melting in Japan. Geothermal Resources Council Transactions, 3, 639-642.

Minohara, Y. & Sekioka, M., 1980: Non-Electric Utilization of Geothermal Water and Steam from Production Wells of Geothermal Power Stations in Japan. Geo-Heat Utilization Center Quarterly Bulletin, 5 (2), 10-41.

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