Status of Japanese HDR project at Hijiori

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Key words: hot dry rock, Hijiori HDR project, HDR resource, cost estimation, circulation test

ABSTRACT

The amount of HDR geothermal resource in Japan was estimated about 1.4×10^{20} cal that will be able to produce 2.9×10^{10} W for 20 years. It is huge enough to supply over 10% of the electricity in Japan. However, the cost of electricity generated from the HDR energy was estimated larger than twice that of petroleum, gas or nuclear power. Thus, the Hijiori HDR project will be prolonged until 2000.

The major achievement of the Hijiori HDR project was a circulation test for 90 days in 1991. Water was injected ihto an injection well, heated through the 1800-m-deep reservoir and ejected from three production wells. A production rate was about 46 ton / hour while an injection rate was 60 ton / hour, and a thermal output was about 8 MW. After the circulation test, a 2200-m-deep reservoir with an injection well and two production wells was completed in FY 1994. From FY 1996 to FY 1998, a long term circulation test will be conducted.

Reservoir	Temperature (°C)	Wells connected with the reservoir
1800-m-deep reservoir	about 250 degrees	SKGZ, HDR-2 and HDR-3 (HDR-1*)
2200-m-deep reservoir	about 270 degrees	HDR-I, HDRZ and HDR-3

Well	Depth (m)	Bottom of casing (m)	Maximum temperature (°C)
SKG-2	1,802	1,788	253
HDR-1	2,205	2,159	271
HDR-2	2,300	1,510	
HDR-3	2,303	**1,516**	262*

1. Organizations responsible for the HDR project at Hijiori

Three organizations are responsible for the Hijiori HDR project. The first is the Geothermal Energy Technology Department of NEDO. The second is the New Sunshine Project Promotion Headquarters (NSPPH) of the Agency of Industrial Science and Technology (AIST). The third is the National Institute for Resources and Environment **(NIRE)** of AIST. NSPPH makes the energy policy to develop renewable energy or to increase the energy efficiency. NEDO plans the energy projecls adequate to the policy and manages the projects by the national budget. The Geothermal Energy Section of NIRE makes advice for the Hijiori project. Several members of the section participated in the Fenton Hill HDR project while Japan collaborated with it.

2. Underground system at Hijiori

At present, the HDR system consists of two reservoirs and four wells as shown in Tables 1 and 2. The 1800-m-deep reservoir was stimulated by water injections into SKG-2 in 1986 and two years later. The 2200-m-deep reservoir was stimulated by water injection into HDR-1 in 1992. SKG-2 had been drilled by a geothermal developing company before the HDR project. HDR-1 was drilled 1,805 m deep in 1987 and was deepened to 2,205 m one year later. HDR-2 was drilled 1,910 m deep in 1989 and was deepened to 2,300 m in 1994. HDR-3 was drilled 1,907 m deep in 1990 and was deepened to 2,303 m in 1993.

Year	Major achievement
1985	The site was located at the foot of a mountain surrounding the Hijiori caldera.
1986	The 1800-m-deep reservoir was stimulated by water injection into the SKGZ.
1987	HDR-1 was drilled 1,805 m deep.
1988	Flow test of the 1800-m-deep reservoir was run between SKG-2 and HDR-I. Afterwards, HDR-1 was deepened to 2,205m.
1989	HDR-2 was drilled 1,910 m deep. Afterwards, the one-month circulation test was run between an injection well and two production wells.
1990	HDR-3 was drilled 1,907 m deep.
1991	Three-month circulation test was run and generated thermal energy of 9 MW.
1992	The 2200-m-deep reservoir was stimulated by water injection into HDR-1.
1993	HDR-3 was deepened to 2,303 m.
1994	HDR-2 is deepened to about 2,300 m.
1995	A preliminary circulation will be carried out.
1996	The long-term circulation test will be prepared.
1997	The long-term circulation test will be started.
1998	The long-term circulation test will be continued.
1999	The long-term circulation test will be finished.

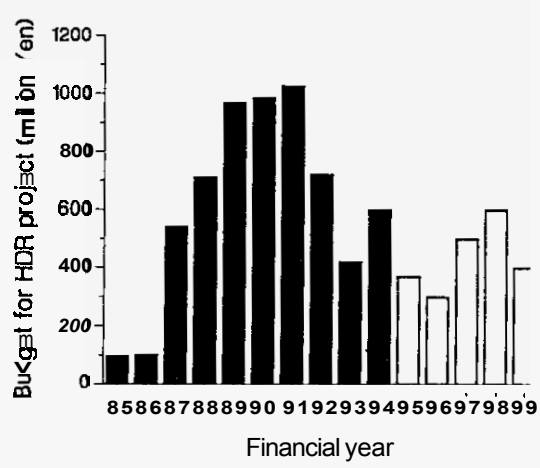

Fig.1 Budgets of the HDR project of NEDO

4. Estimation of the **HDR** geothermal resource in Japan

The amount of HDR geothermal resource was estimated by surface survey data and well data of 29 geothermal area in Japan. 195 wells were drilled to about 1,000 m in the regions. Among the wells, 118 wells were selected to estimate the HDR resource, because the temperature distributions of them were thermally conductive and the temperature at 3,000 m deep extrapolated linearly was over 250 "C. We used the following equation to calculate the HDR resource of each region.

$$Q = D \times C \times A \times \int_{x_0}^{3000} (T(x) - 15)dx$$

where, D is the density of rock and is supposed as 2700 kg/m^3, C is the specific heat of rock and is supposed as 200 cal/kg/K, **A** is the area of the region, x is the depth, x_0 is the depth where the temperature was estimated to reach 250 °C, and, T(x) is the temperature at the depth of **x.** temperature of the selected wells. The boundary of each geothermal region was roughly drawn by surface data and its area A was calculated. The limit of the depth was set at 3,000m because we have enough technology to drill a well to 3,000 m. The total HDR resource in the 29 regions was estimated about 1.4×10^{20} cal that will be able to produce 2.9×10^{10} W for 20 years.

5. Estimation **of** the cost of **HDR** power generation

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De th of the reservoir	2,000 m
Initial roduction tem eratnre	250 °C
Reinjection tem erature	100 °C
Water loss	
Injection rate into one injection well	not larger than 500 t/h
Drilling cost for a 2,000 m deep well	500 million Yen
Stimulation cost at the depth of 2,000 m	80 million Yen
Construction duration	2 years for 3 MW plant, 4 years for 10 MW one and 5 years for 30 MW one
Operating duration	not less than 15 years
Power generation after 15 years	not less than 90 % of the initial power generation
Number of operators	5 for 3MW plant and 20 for iargerones

Power generation capacity (MW)	Unit cost (million Yen/MW)	Electricity cost (Yen/kWh)
3	1,640	36
10	1,180	28
30	900	22

The HDR project will not be terminated because the resource of HDR in Japan is huge enough to supply over 10 % of the electricity in Japan. However, the cost of electricity generated from the HDR energy was estimated larger than twice that of petroleum, gas or nuclear power. Thus, the Hijiori project will be prolonged until 2000. The ways to realize earlier HDR power generation in Japan are to reduce the costs of drilling and hydraulic stimulation and to increase the worth of HDR resources by direct heat use of hot water produced at the plant. We think that the main technological problems of HDR power generation are to estimate the life of a HDR reservoir and to make it larger. We are planning a long-term (we think it means about 2 years) flow test through the 2200-m-deep reservoir in 1997, 98 and 99. We hope the test will produce cnough data to solve the problems.