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GEOTHERMAL ENERGY IN JAPAN

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Japan's Energy Situation Japan is short of almost every important mineral resource and is entirely or almost entirely dependent on imports. Worst of all, it is almost completely lacking in petroleum, a key energy resource, and this energy source currently accounts for roughly three quarters of total Japanese energy consumption.

Japan's energy consumption is second in the free world following the United States. However, per capita energy consumption is about one-third that of the United States or Canada.

Alternative Energy Development and Targets for Geothermal Development MITI, Ministry of International Trade and Industry, studied both the fundamental problems and issues regarding the establishment of targets for the supply of alternative energy in conformity with the "Law Concerning the promotion of Development and Introduction of Alternative Energy Sources."

As the long-term domestic and international energy situation is difficult to predict, it is necessary for Japan to promptly enhance the development and introduction of alternative energy sources in order to secure a smooth supply of energy. Consequently, Japan should endeavor to satisfy at least 50% of her energy demands by means of alternative energy sources in fiscal year 1990.

With the above figure serving as a major goal, alternative sources of energy and their individual supply targets in FY 1990 were studied. Due consideration was given to each energy source's past performance and supply, as well as the effects of various past and future policy measures, before arriving at the following conclusions. Full cooperation is expected from both the government and private sector in order to fulfill these targets.

Through the enhancement and development of geothermal resources, an annual supply target of 7.3 million kl, the equivalent of 3500 MW of facility capacity, has been set for geothermal energy. (Table 1)

According to the Provisional Long-term Energy Supply and Demand Outlook, published by the Energy Advisory Committee of MITI in 1979, targets for the development geothermal energy are 1000 MW in 1985, 3500 MW in 1990 and 7000 MW in 1995. (Fig. 5) It may be necessary to adjust these figures over time and there is currently no geothermal target for the year 2000.

Problems The generation capacity of geothermal power plants in Japan has grown to 162 MW since the inauguration of the first industrial power station in Matsukawa in 1966. (Fig. 1, Table 2) Two new plants are under construction, and combined they will have a capacity of 53 MW by 1982. (Fig. 2) In more than twenty geothermal fields, test wells will be drilled this year. (Fig. 3)

Judging from this data, it will not be easy to attain development targets outlined above.

The government, meanwhile, has established separate policy measures for each of the different types of problems which grow out of efforts to develop such an energy source. Areas in which the government has policy measures strategies include regulatory, technological, financial and environmental problems.

Regulatory Environment and Policy Measures Civil Codes and the Hot Spring Law both affect geothermal development. In addition, the development of fields in natural parks is restricted by the Natural Parks Law.

Several procedures related to the development of a geothermal field are given below. After a comprehensive land survey, the development company drills a test well with drilling permission from a local government, in accordance with the Hot Spring Law. The ownership of the geothermal resource belongs to the landowner according to Civil Codes, and as a result the development company must buy the land.

Although it is preferable for the company to acquire the land ownership for a promising vast field, this is often not realistic because of the expense involved.

In addition, if company B hears about the fact that company A has found a superior geothermal field, these are currently no regulations which would restrict company B from drilling test wells near the field. In other words, there are no legal measures for protection of discoveries and no geothermal exploration rights, such as those resembling mining rights.

The establishment of "geothermal exploration rights" and a revision of Civil Codes and the Hot Spring Law has been suggested. However, it will take more than ten years to revise these laws because thousands of people who make a living with hot springs, will surely oppose such legal revisions. Many Japanese enjoy taking a hot spring bath and hot spring resorts have been popular destinations for travelers for hundred of years.

Another regulatory factor is the Natural Parks Law. More than half of the potential geothermal fields are in natural parks areas including national parks and local parks. Before drilling a test well in a natural park, a geothermal development company must have drilling permission according to the Natural Parks Law. Some people are very reluctant to have geothermal power plants in a natural park because of their "poor looks, dirty hydrogen sulfide(H_2S) and polluted hot water."

In response to this, one proposal is to enact a geothermal promotion law, which would make it unnecessary to receive drilling permission under the Hot Spring Law and Natural Parks Law. This may prove to be not feasible.

Technological Problems and Policy Measures

Following the oil crisis in 1974, the "Sunshine Project,"aiming at research and development of new technology for solar, geothermal, coal and hydrogen energies, was started. Areas of technological development addressed in the Sunshine Project for Geothermal Energy are outlined as follows:

(A) Technology for exploration and extraction of geothermal energy Current exploring techniques largely depend upon those used for petroleum resource exploration, both in method and equipment. However, in order to attain adequate precision in the future, new exploring techniques suited to geothermal prospecting are necessary and will be developed.
With regard to geothermal well drilling techniques, progress is being made in applying the air drilling method as well as the conventional mud drilling method. In the future, drilling will be made into rocks with even higher temperatures(300 - 400 ℃); therefore, the development of high temperature and corrosion resistant materials is compulsory.
Together with a drilling machine, much more severe conditions will be imposed on the well logging instruments, with respect to their heat resistance, pressure resistance and corrosion resistance; consequently, efforts must be made to improve their performance capabilities. In the interests of preventing environmental disruption and reducing heat loss, incline drilling may also be widely adopted.
Consequently, the object of studies is to establish methods for confirming the amount of geothermal deposits and to develop technology for exploring and assessing geothermal resources as well as technology for excavating high-temperature rock in order to reduce the risks involved in development.

(B) Technology for power generation utilizing hot water The power generation system today is limited to the use of natural steam, but the effective use of hot water associated with natural steam must be developed. For this purpose, the development of binary cycle power generating system using low enthalpy fluids such as Freon or Isobutane as the carrier of heat energy, a combined cycle system combining the former with the natural steam system and the total flow generation system are expected.

The object of studies is to develop the technology for corrosion-resistive materials, technology for high-efficiency heat exchange, etc., and to develop a high-efficiency binary-cycle power generating system by late 1980's. Test runs were undertaken on a 2-system(1 MW hot water type, combination hot water and steam type). A 0.3 MW system has been developed in order to develop the high-efficiency two-phase flow rotary expander.

(C) Technology for a hot dry rock power generating system The development of hot dry rock fracturing techniques and artificial hot water and steam evolving system for extracting thermal energy possessed by hot dry rock is very important and a challenging theme.

There is a high potential for the development of these power generation systems, utilizing the aforementioned techniques of forming artificial hot water and steam systems.

Therefore, studies are being carried out to develop technology for fracturing hot dry rock, technology for forming manmade hot water and steam systems, etc., and to develop high-efficiency and large-capacity hot dry rock power generating systems by the middle of 1990's.

(D) Technology for multi-purpose utilization of geothermal energy and environmental preservation Effective use of hot water associated with geothermal power generation is important in view of reducing power generating costs by allocation and the contribution to regional development. The power generating plant for multi-purpose use of geothermal energy may be called a local welfare type plant. The multi-purpose use of geothermal energy will also be highly effective in preventing environmental pollution caused by the discharge of hot waste water.

Environmental effects brought on by geothermal fluids must be fully controlled. These include corrosive gases and chemical components discharged from geothermal fluids, as well as hot water and solids, adversely affecting humans and the ecological systems. It is imperative that comprehensive techniques for environmental protection should be established.

Therefore, studies are being carried out to develop technology for transporting geothermal fluids, and to develop geothermal energy utilization systems for regional heating, agriculture and other purposes.

Furthermore, studies aimed at developing technology for environmental preservation in order to prevent adverse effects on the natural environment and ecosystem from the extraction and utilization of geothermal fluids are being carried out.

Financial Problems and Policy Measures Among nuclear, geothermal, coal, gas, oil and hydroelectric energy, geothermal is not the cheapest (nuclear), nor is it the most expensive(hydroelectric).

A geothermal development requires a large amount of investment and assumes large risks in the exploration of a promising field. Therefore, it is important to reduce these financial burdens by giving financial incentives including subsidies, low interest loans and preferential tax treatment. The government itself may also support various surveys directly.

The first of these government supported surveys is the nationwide geothermal resources survey which has been undertaken by the newly established New Energy Development Organization (NEDO). The NEDO is almost fully supported by the government. In this three-year project, potential areas will be re-evaluated by Landsat data, gravity data, Qurie-point analysis data, and synthetic aperture radar data. The survey has just begun to collect radar data and the results of this survey will be available after all the data has been completed.

As a second type of survey, local rough surveys have been carried out by NEDO with government funds in several areas. Under this survey, in each selected area, five geothermal survey wells(1000 m depth) and two wells (1500 m depth) will be drilled for two years. At the same time, air and water pollutants, as well as hot springs have also been investigated.

Thirdly, the government encourages private companies through a test-well drilling subsidy. A company can receive one-half of the expenditures for test-wells from the government and it must repay the government if the company successfully builds and operates a plant.

Fourth, the Japan Development Bank and Hokkaido-Tohoku Development Bank have played an important role in promoting geothermal development by providing low interest loans. The fact that these banks give a loan to a company serves as a signal to the "city banks" that the company is worthy of commercial credit.

Finally, special accelerated depreciation rules and tax credits are applied to companies that have invested in geothermal plants or geothermal green houses.

Combined, these five measures reduce business risks and have accelerated developments in the private sector.

Environmental Problems and Policy Measures The impact of the establishment of geothermal power plants on the environment may be divided into three areas; bad appearance, dirty hydrogen sulfide and arsenic hot water.

There are some people who, in order to preserve the scenic beauty of natural areas, are opposed to geothermal plants because of the appearance of mechanical facilities; pipelines, transmission and cooling towers. Recently electric companies have been attempting to cover the facilities with natural plants and trees, or lower building heights.

Secondly, geothermal plants discharge hydrogen sulfide (H_2S) into the atmosphere. Under the provisions of the Offensive Odor Control Law (not the Air Pollution Control Law), the discharge of hydrogen sulfide(H_2S) is regulated, except hot spring areas. Hot springs naturally discharge quite a lot of H_2S and this is most often above the emission standard. All the geothermal plants in hot spring areas have large cooling towers and discharge H_2S together with large amounts of fresh air and steam through these. In addition to these efforts, the Environment Agency plans to implement H_2S regulations similar to those of Northern Sonoma County, California and as a result, H_2S emission control technology has been developed by the Agency of Industrial Science and Technology, MITI.

Finally, geothermal water usually contains arsenic at levels above the environmental quality standard; 0.05 ppm. Therefore, all the hot water utilized in a plant is re-injected into the earth in order to prevent water pollution. In addition to this measure, the Kyushu Electric Power Co. has developed arsenic control technology with a government subsidy. Unfortunately this control technology cannot as of yet, be utilized. Although many people near a geothermal plant hope to have "hot spring water" by means of this new arsenic control device, some people are very reluctant to agree to use this device even though quite a number of Japanese drink a cup of arsenic spring water for medical treatment.

New technologies and new layout techniques make geothermal plants much more appealing to people.

Strategies for Consensus Building People who are used to enjoying hot springs worry about hot springs drying out because geothermal plants use much more geothermal energy than hot springs. Some people are therefore even opposed to surveys. In order to demonstrate large-scale hot water utilization, several national projects were begun in 1980 with the financial support of MITI. Among these, the largest project attempts to produce up to 800 t/h of 115℃ water from river water through a heat exchange process utilizing 1000 t/h, 150℃ used, geothermal water. This 115 ℃ water is then transported to twelve villages. This is, in direct utilization of geothermal resources in Japan, the first project to supply water at over 100℃. It will take four years to construct and will require $20 million.

Conclusions By the end of this year, I expect to see very significant achievements realized as a result of our efforts. These include the completion of the nation wide air-borne survey. the compiling of over 20 sets of logging data from five local surveys, and I expect more than fifty test wells to be completed in twenty different areas.

From a technical and social stand-point, this year will be critically important. It is my sincere hope that our combined efforts will prove to be Japan's first giant step toward the implementation of geothermal energy systems.

Table 1. Alternative Energy Supply Targets FY 1990
approved by the Cabinet on November 28, 1980

Types of Alternative Energy Sources to Be Developed and Introduced and Their Supply Targets

Types of alternative energy sources	Supply target * (Unit: 10,000 kl)		Remarks	(Reference) FY 1977 (Unit: 10,000 kl)	
Coal	12,300	35.4%	The supply of coal is 163.50 million tons.	5,681	50.9%
Nuclear energy	7,590	21.8%	The supply capacity of nuclear energy is reflected in the electricity generated at nuclear power plants. The output of nuclear plant facilities is between 51.00 and 53.00 million kilo watts and the annual amount of electricity generated is 292.0 billion kilo watt hours.	1,542	13.8%
Natural gas	7,110	20.4%	The supply of natural gas is the sum of the quantity of imported natural gas (45.00 million tons) and domestic natural gas (7.60 million tons).	1,940	17.4%
Hydro-electric energy	3,190	9.2%	The supply of hydroelectric energy is equivalent to the electricity generated at hydroelectric power plants. The output of hydroelectric power plants is 53.00 million kilo watts. Within this total, 26.00 million kilo watts come from general hydro-electric power plants (including all types of hydroelectric plants except pumped-storage power plants) and 27.00 million kilo watts come from pmped-storage hydroelectric power plants. The annual amount of electricity generaged is 123.0 billion kilo watt hours.	1,941	17.4%
Geothermal energy	730	2.1%	Geothermal energy includes electricity generated by thermal power plants utilizing geothermal energy. The output of these facilities is 3.50 million kilo watts and the annual amount of electricity generated is 24.5 billion kilo watt hours.	16	0.2%
Other alternative energy sources	3,850	11.1%	Other alternative energy sources include solar energy, coal liquefaction fuel, etc.	38	0.3%
(Reference) Total	350 million kl	100.0%		112 million kl	100.0%

(Note)* The supply target of alternative energy sources represents figures which have been converted into equivalent crude oil quantities.

Table 2. Geothermal Power Plants (inclusive of those under construction, as of April 1981)

	Name of Power Station	Name of Company	Location	Maximum Capacity (MW)	Year of Commission	Electric Production FY 1979 (Gwh)	Conversion Cycle	Inlet Temp. ℃	Inlet Pressure ata
Existing Facilities	Matsukawa	Japan Metals and Chemicals Co., Ltd.	Iwate Pref.	22	1966	176	-	190	3.5
	Otake	Kyushu E.P.Co.	Oita Pref.	12.5	1967	64	Flash	127	2.5
	Onuma	Mitsubishi Metal Co.	Akita Pref.	10	1974	62	Flash	114	1.8
	Onikobe	E.P.D. Co.	Miyagi Pref.	12.5	1975	59	Flash	134	1.7
	Hatchobaru	Kyushu E.P.Co.	Oita Pref.	55	1977	376	Double Flash	164	7.0
	Kakkonda	Tohoku E.P.Co. Japan Metals and Chemicals Co., Ltd.	Iwate Pref.	50	1978	364	Flash	140	3.5
Under Construction	Mori	Hokkaido E.P.Co. Donan Chinetsu Energy Co.	Hokkaido Pref.	50	1982	-	Double Flssh	164	7.0
	Suginoi	Suginoi Hotel	Oita Pref.	3	1982	-	Flash	140	4.0

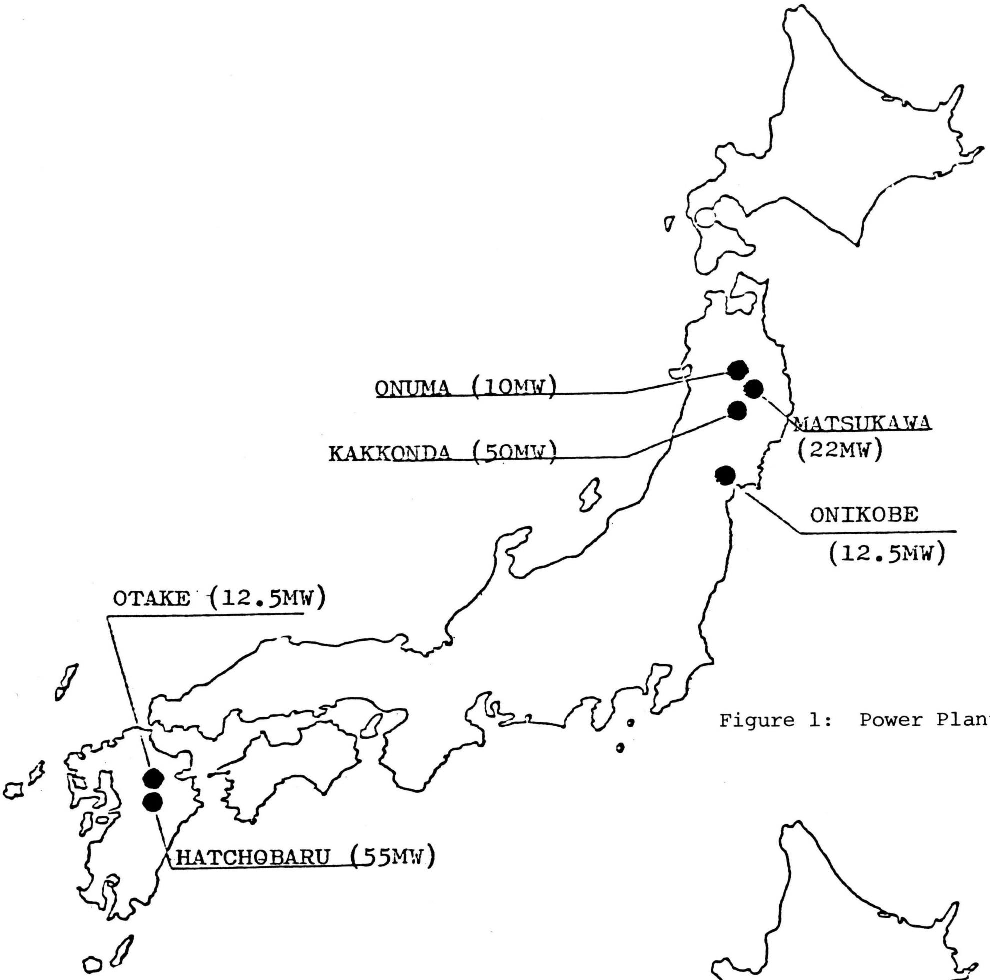


Figure 1: Power Plants On-Line

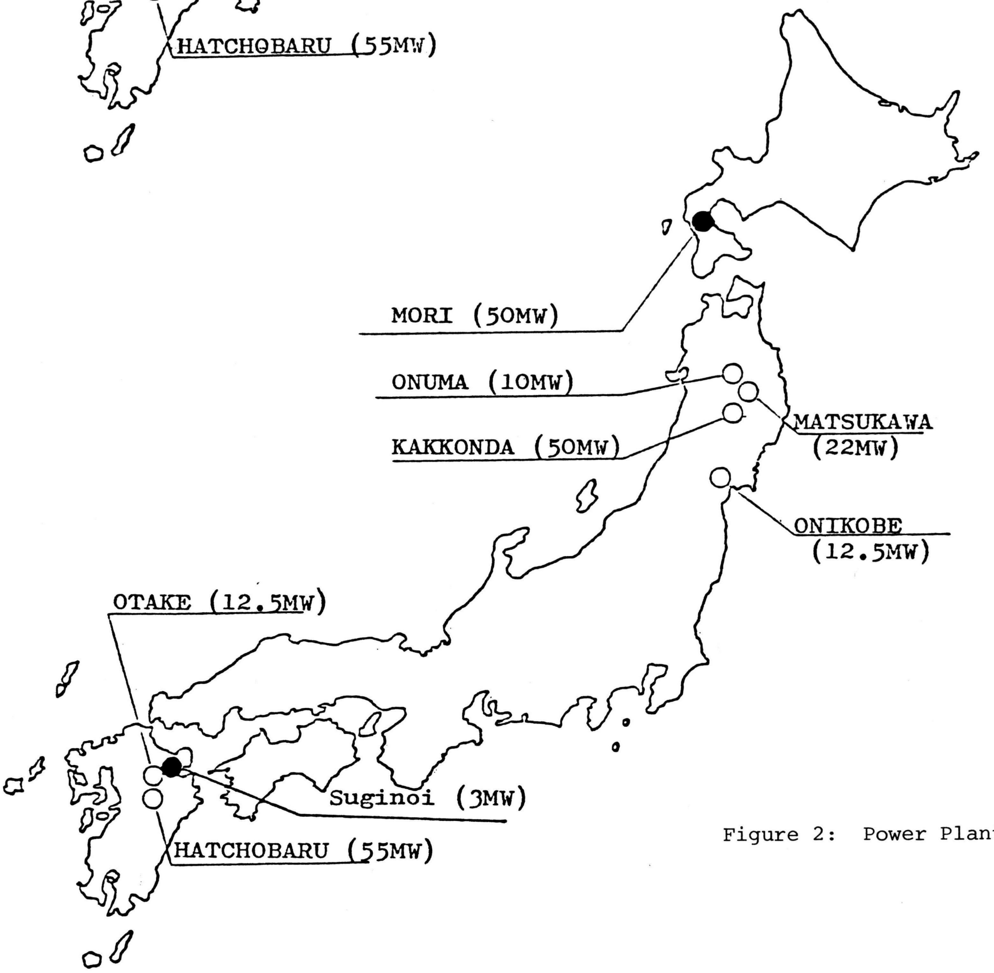
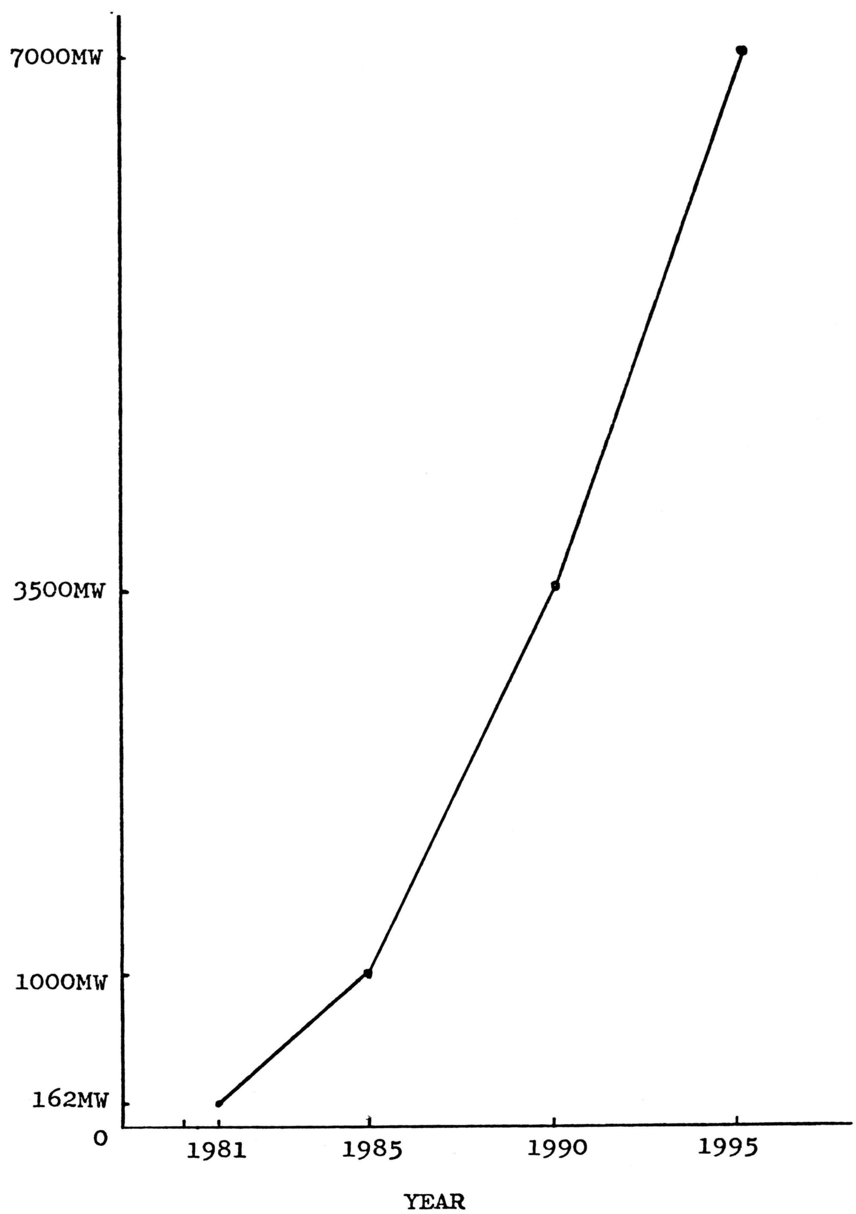


Figure 2: Power Plants Under Construction

Figure 3: Power Plants Planned

Figure 4: Hot Water Utilization

Figure 5: Geothermal Energy Target



Annex

Geothermal Projects Planned for Fiscal 1981

Unit: million yen
(million $)$1=¥210

Project Name	Budget for FY 1981	Budget for FY 1980
Nationwide geothermal resources survey	2,518 (12)	1,846 (9)
Local rough surveys	2,754 (13)	2,600 (12)
Test-well drilling subsidies	2,728 (13)	2,401 (11)
Environmental assessment of large scale power generation using deep geothermal reservoir (Hohi)	2,604 (12)	3,004 (14)
Field survey to test geothermal resource exploration technology (Sengan, Kurikoma)	1,012 (5)	539 (3)
Hot water utilization projects	1,663 (8)	932 (4)
Hot water supply from deep geothermal reservoir	678 (3)	262 (1)
U.S.-Japan joint research on power generation on hot dry rock. etc.	600 (3)	603 (3)
Others	2,609 (12)	2,736 (13)
Total	17,166 (82)	14,923 (71)