SUMMARY

Commissioned Project on Precision Survey and Analysis of Geothermal Power Generation Introduction Potential (FY 2013)

To promote global warming prevention and ensure energy security, it is important to make further efforts for reinforcement of renewable energy. Particularly after the Great East-Japan Earthquake and the disaster of the Fukushima First Nuclear Power Plant, there has been a growing need for these efforts. Among others, renewable energy ensures more stabilized power generation than the solar power or wind power generation. It is extremely important to encourage the geothermal power generation as a base power source.

In Japan, however, there is no new site for geothermal power generation in recent years (after the construction of Hachijojima geothermal power plant in 1999). This will be due to the high development risk and cost as well as difficulties in reaching agreement with the local authorities for development. To reduce the geothermal development risk, it is essential to obtain more precise information on the distribution of geothermal power generation resources and to share information among the related peoples.

With respect to the geothermal power generation introduction potential, the Ministry of the Environment has been implementing a "renewable energy introduction potential survey and "collection of zoning basic information on renewable energy" since fiscal 2009, and has make estimates on a nation-wide scale. This project is intended to upgrade precision of the information on the distribution of geothermal power generation resources, to make a more precise estimate of the introduction potential than that of the conventional surveys and to enhance the convenience of wide-ranging business operators involved in geothermal development.

1. Collection and organization of related information

We have collected and organized the topographic and geographical data, hot spring data and existing well data required to estimate the density of the geothermal power generation resources.

2. Estimate of underground temperature structure

Using the hot spring data and well temperature profile data having been collected or organized, we estimated the underground temperature structure on a nationwide scale by depth (at intervals of 50 meters) in units of 500-meter mesh. To put it more specifically, we picked up 8,254 points on available hot spring data and calculated the

Activity Index (AI) for each hot spring point, thereby creating temperature profile data across the depth. For 459 points in 67 regions where we could obtain the well data of higher precision than hot spring data, we created the temperature profile data for each elevation and replaced the data (in units of 500-meter mesh). Correction and interpolation were conducted by the principle of least curvature for each depth, with the result that underground temperature structure was estimated on a nationwide scale (Figures 1 to 3).

To visualize the underground temperature structure at a given site, we created an "underground temperature structure visualization tool" capable of visualizing the underground structure database (temperature data by 500-meter mesh/depth (at intervals of 50 m)).

This tool was utilized to configure the following two functions:

①Creation of temperature distribution diagram by depth in a given range (approximately 10-km mesh assumed)

②Representation of underground temperature data at a given point (center of 500-meter mesh) (or graphic representation)

Figure 1 Underground temperature structure data (G.L. 0 m)

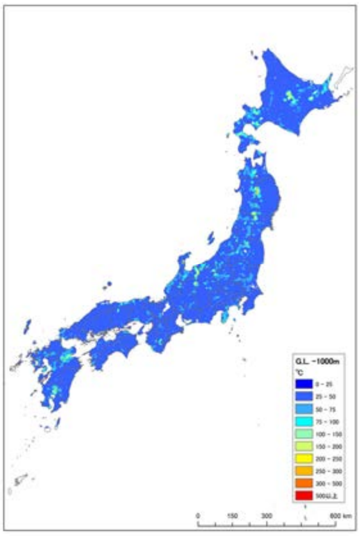

Figure 2 Underground temperature structure data (G.L. -1000 m)

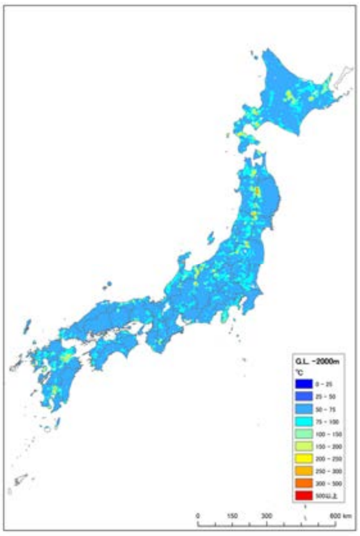

Figure 3 Underground temperature structure data (G.L. -2000 m)

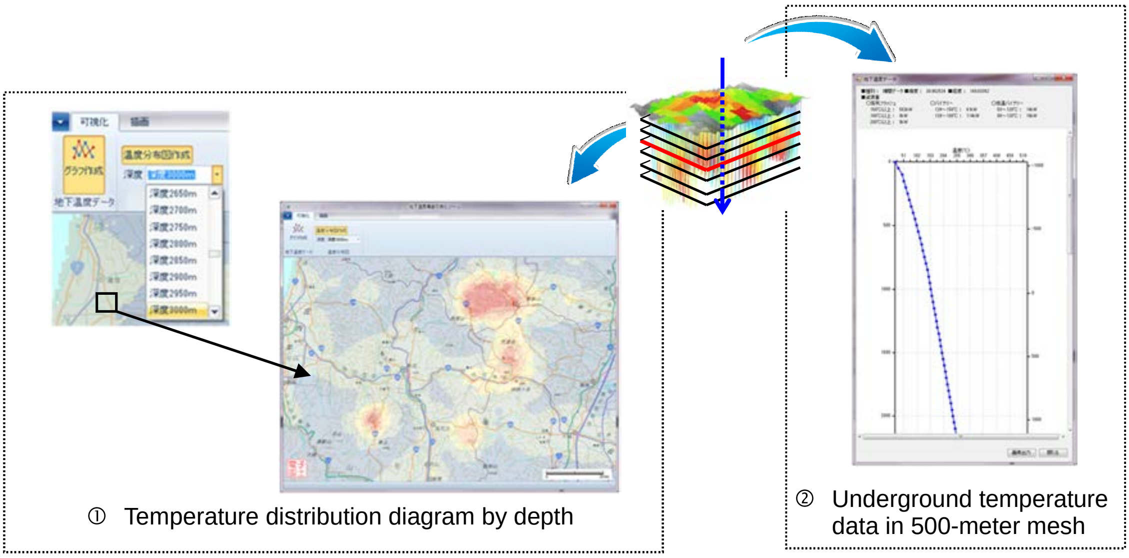

Figure 4　Underground temperature structure visualization tool

3. Creation of reservoir bedrock elevation diagram for hydrothermal resources

Using the geochemical temperature gauge for the existing geographical data, gravity bedrock depth and hot spring data (a technique for estimating the underground temperature from the result of componential analysis of hot spring water), we estimated the reservoir bedrock elevation (reservoir bottom elevation) in units of 500-meter mesh and created a reservoir bedrock elevation diagram (Figures 5 and 6).　For estimation, the New Tertiary system and Quaternary system were assumed to be the stratus where the hydrothermal reservoir bedrock was allowed to be present.　Further, since the geochemical temperature gauge does not provide an effective means for all the hot springs, we used it after specifying the type of hot spring where this technique was valid.

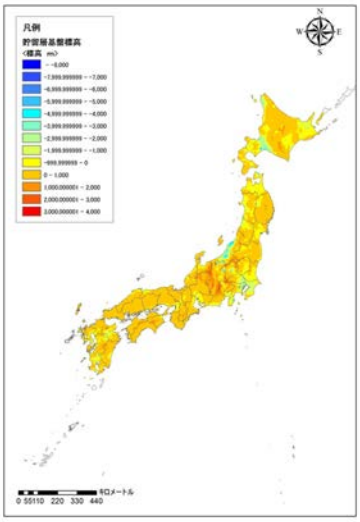

Figure 5　Reservoir bedrock elevation diagram (across Japan)

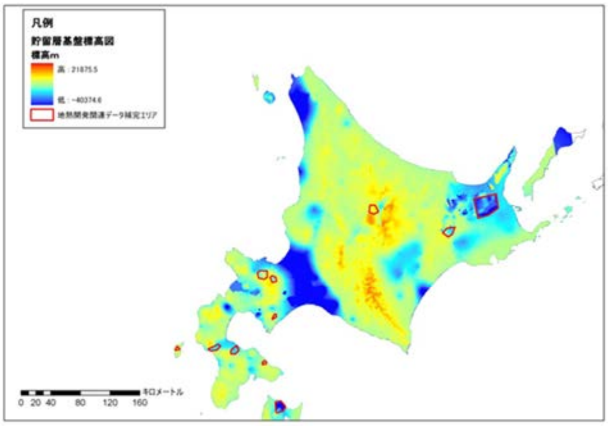

Figure 6　Reservoir bedrock elevation diagram (sample: Hokkaido)

4. Setting the scope of possible reservoir bedrocks and creation of resource density distribution diagram based on the USGS volumetric method

After having studied the scope of possible geothermal reservoir bedrocks, we created a distribution diagram by estimating the resource density using a USGS volumetric method.　The following illustrates the assumptions used for estimation:

1)The reference temperature and power generation efficiency were assumed for each power generation method.

2)More than one applicable lower limit temperature was assumed.(Steam flash: 150°C, 180°C, etc.)

3)In the previous surveys, the low-temperature binary (hot spring power generation) lower limit temperature was set at 53°C.　Based on the result of hearing in the survey for last fiscal year, the low-temperature binary (hot spring power generation) lower limit temperature was also set for 80°C which is the current practical lower limit temperature.

4)To estimate the resource density (kW/km2), the volume of resources assessed by the USGS volumetric method was divided by 30 on the assumption that this volume would be used during the 30-year period.

Figures 7 to 9 illustrate the resource density distribution diagram having been created, while Table 1 shows the volume of geothermal resources (across Japan).

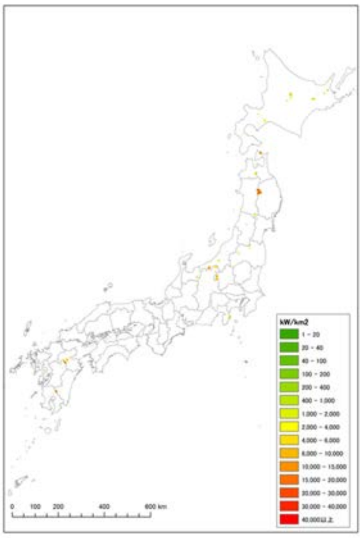

Figure 7　Resource density distribution diagram (Steam flash 150°C or more)

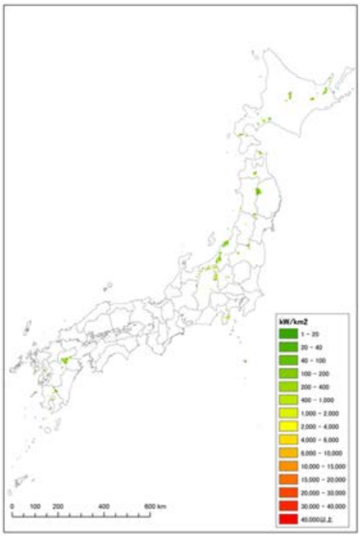

Figure 8　Resource density distribution diagram (Binary (Rankine cycle assumed) for 120 to 150°C or more)

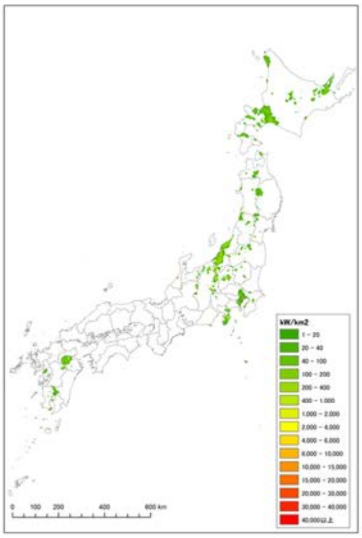

Figure 9　Resource density distribution diagram (Low-temperature binary (Carina cycle assumed) for 53 to 120°C or more)

Table 1　Calculation of the volume of geothermal resources (across Japan)

Power generation method	Target temperature classification	Volume of geothermal resources (unit: 10,000 kW)	Reference: Estimated in 2010 (*) Volume of geothermal resources (unit: 10,000 kW)
Steam flash	150°C or more	2,219	2,357
	180°C or more	1,314	Not estimated
	200°C or more	933	Not estimated
Binary (Rankine cycle assumed)	120 to 150°C	120	108
	120 to 180°C	239	Not estimated
Low-temperature binary (Carina cycle assumed)	53 to 120°C	199	849
	80 to 120°C	143	Not estimated

* This estimate is based on the geothermal potential map created by the Institute of Advanced Industrial Science and Technology in a project "Renewable energy introduction potential survey for fiscal 2010", Ministry of the Environment.

5. Creating the resource distribution chart on hot spring power generation

Based on the hot spring data (3,702 spots) having been collected or organized, we extracted 149 spots where the hot springs would meet the requirements of water temperature of 80°C with a volume of 100 L per minute, which were determined as hot spring power generation requirements.　Further, we studied the procedure for estimating the facility capacity compatible with hot spring power generation. For these hot springs, we estimated the volume of possible hot spring power generation where the Carina and Rankine cycles were assumed. This calculation has yielded 76,500 kW for the Carina cycle and 41,400 kW for Rankine cycle. Figures 10 and 11 illustrate the resources distribution chart for hot spring power generation.

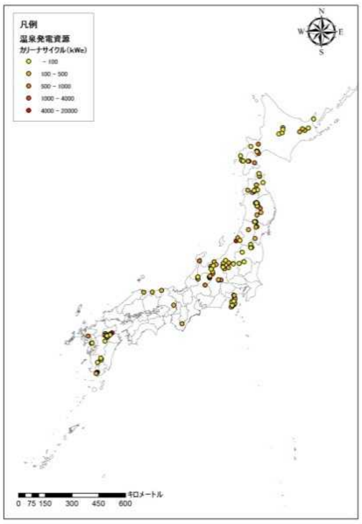

Figure 10 Resource distribution chart for hot spring power generation where Carina cycle is assumed

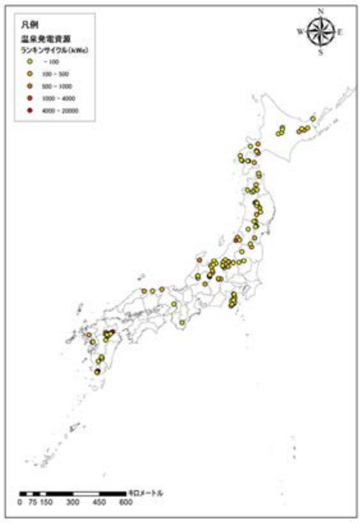

Figure 11 Resource distribution chart for hot spring power generation where Rankine cycle is assumed

6. Re-estimation of introduction potential

We determined the requirements for the development in the National Parks (special area of Classes 2 and 3) and requirements for the development by slant excavation, and estimated three types of introduction potential. The introduction potential distribution chart is illustrated in Figures 12 to 14, and the result of summary is given in Table 2. For the steam flash power generation of 150°C or more, comparison was made between the result of survey this year and the result in past years. It has been revealed that the result of this year is about three times greater than that of the past years. This is considered to be due to the addition of the well data. In the meantime, the low-temperature parity generation of 53 to 120°C is about 20 percent smaller than the result in the past years. This is because dummy data (AI=0) was added in the areas devoid of temperature data within 5 km on the periphery, with the result that the underground temperature in these areas was reduced below that in the previous years.

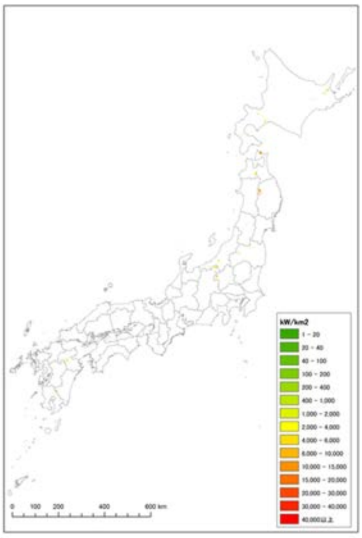

Figure 12 Steam flash introduction potential distribution chart (150°C or more, basic)

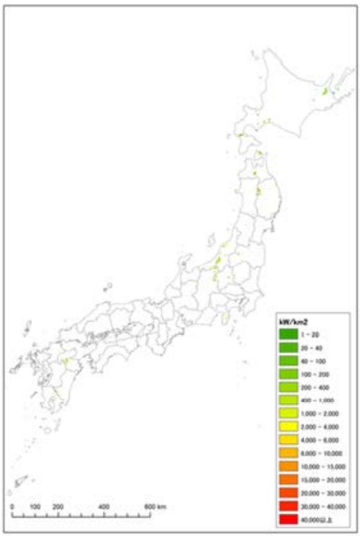

Figure 13 Binary power generation introduction potential distribution chart (120 to 150°C or more, basic)

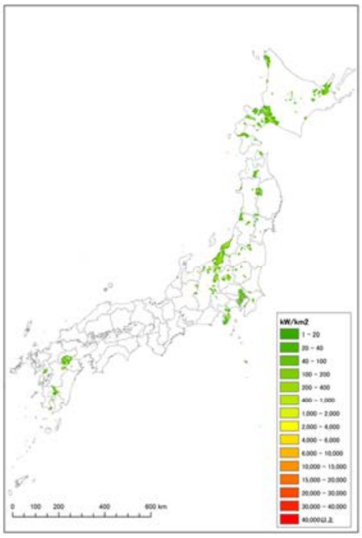

Figure 14 Low-temperature binary power generation introduction potential distribution chart (53 to 120°C or more, basic)

Table 2 Steam flash introduction potential summary result

Power generation method	Temperature classification	Estimation requirements	Introduction potential (unit: 10,000 kW)	(Reference) Result of estimation by the survey in past years
Power generation by steam flash	150°C or more	Basic (without National Park or slant excavation)	785	233(*1)
		Requirement 1 (without National Park or with slant excavation)	1,267	534(*1)
		Requirement 2 (with National Park without slant excavation)	1,407	848(*1)
	180°C or more	Basic (without National Park or slant excavation)	446	Not yet estimated
		Requirement 1 (without National Park or with slant excavation)	787	Not yet estimated
		Requirement 2 (with National Park without slant excavation)	887	Not yet estimated
	200°C or more	Basic (without National Park or slant excavation)	313	Not yet estimated
		Requirement 1 (without National Park or with slant excavation)	574	Not yet estimated
		Requirement 2 (with National Park without slant excavation)	648	Not yet estimated
Binary power generation	120 to 150°C	Basic (without National Park or slant excavation)	49	33(*2)
		Requirement 2 (with National Park without slant excavation)	68	Not yet estimated
	120 to 180°C	Basic (without National Park or slant excavation)	93	Not yet estimated
		Requirement 2 (with National Park without slant excavation)	136	Not yet estimated
Low-temperature binary power generation	53 to 120°C	Basic (without National Park or slant excavation)	171	751(*2)
	80 to 120°C	Basic (without National Park or slant excavation)	121	Not yet estimated

* 1 Result of estimation according to "Organization of basic zoning information for renewable energy for fiscal 2012", Ministry of the Environment

* 2 Result of estimation according to "A survey of renewable energy introduction potential for fiscal 2010", Ministry of the Environment.

7. Verification of the estimation result

We made a comparative verification of the power generation capability of the already developed geothermal power plant and the capacity of the virtual facilities. As a result, the volume of the resources was verified for the geothermal power plant that had already been developed, where the volume of resources had not been found out in the survey of the previous years. Further, a hearing was conducted with two business operators for geothermal development on the overall survey results for the purpose of verifying the adequacy and validity.

8. Subsequent problem

The problem with the estimation of underground temperature structure is how to cover the shortage of information and how to handle the high temperature in the deep part.
In the creation of an elevation chart of reservoir bedrock for hot water resources, it is important to find out ways for covering the shortage of the information on the permeability of the ground and to develop a chemical technique including use of a geochemical temperature gauge. In creating the resources density distribution chart and the like, the problems to be solved will be how to set the lowest possible temperature for power generation according to each power generation method, how to verify the adequacy of the parameters in the volumetric method, and how to ensure consistency with the actual conditions of power plants. The problem with the hot spring power generation is how to cover the shortage of data on the volume of hot water and information on steam wells. Further, the common problem is how to ensure coordination and cooperation with various forms of agencies and organizations that will promote expansion of the relevant area for detailed surveys, establishment of less costly survey techniques, and collection/organization of information.