AMT/NEWSLETTER

Energy

November, 2025

Recent Development over "Next-Generation" Geothermal Power in Japan

Yoshiaki Otsuki

Contents

1. Introduction

In these years, there has been some discussions with respect to "next-generation" types of geothermal power generation not only in Japan but also in some other countries. As such we would like to make some thoughts over those "next-generation" types of geothermal, including some legal aspects applicable to them.

As the starting point, here is some basic information which refers to the development of "next-generation" type of geothermal projects in Japan as follows:

In the current "Basic Energy Plan" (Seventh Basic Energy Plan, as formulated in February 2025) of Japanese government, "next-generation" geothermal power generation is referred to as follows (cited from P. 41 of the Basic Energy Plan):

> "*Japanese companies are participating in the overseas demonstration projects, such as closed-loop and enhanced geothermal systems that can generate power even in areas without geothermal hot water. In Japan, organization such as NEDO and AIST are conducting research on supercritical geothermal energy, which utilizes high-temperature, high-pressure hydrothermal fluids deep underground. In order to realize a drastic expansion of geothermal power generation, R&D and demonstration of these next-generation geothermal power*

generation technologies will be promoted with the aim of commercialization in the early 2030s."

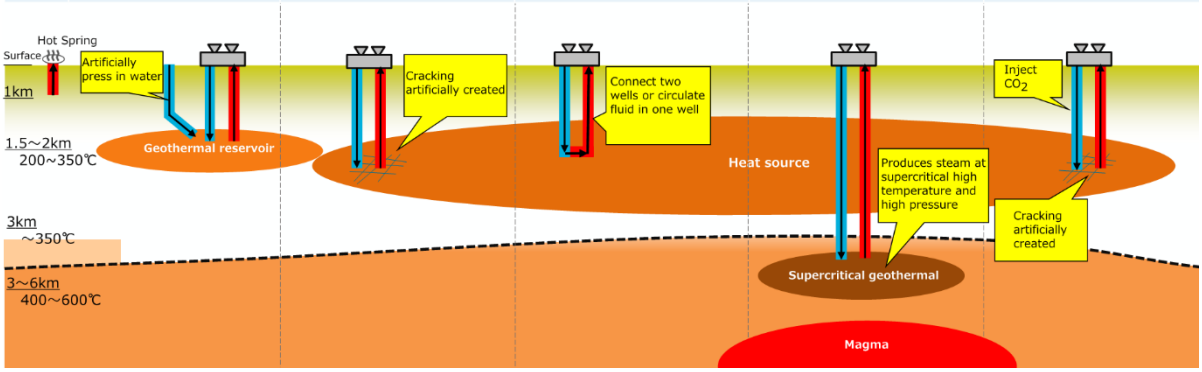
In line with the basic policy of the above-mentioned Basic Energy Plan (the seventh), the Ministry of Economy, Trade and Industry ("METI") has been discussing and examining the development of "next-generation" geothermal power. For this purpose, a public-private council for the promotion of "next-generation" geothermal power was organized inside METI as a working group, being aimed at the practical use of "next-generation" geothermal power. As of the date hereof, the first to fourth meetings of the council have been held. The aim of this council is set out as followed:

"*The goal is for METI to draw up a roadmap after discussions between the public and private sectors, in order to drastically expand the introduction of geothermal power and achieve early practical use.*"

2. Types of "Next-Generation" Geothermal Power and Major Challenges

Reference:Major Types of Geothermal Power Generation

	Conventional geothermal area	"Next-Generation" geothermal area			
	Treatment Injection	EGS Enhanced Geothermal Systems	Closed-loop Geothermal System	Supercritical Geothermal	EGS using Carbon Dioxide
Overview	Water is injected artificially into geothermal reservoirs and the steam is used to generate electricity.	A geothermal reservoir is artificially constructed, and water is injected and steam is produced to generate electricity.	A well is drilled in an unfractured, high-temperature geothermal layer to circulate fluid and generate electricity.	High temperature and high pressure fluid (supercritical hot water) above magma is used for power generation.	CO2 is used for reservoir formation and heat recovery of EGS.
Status	In 1996, water was injected into the Yanaizu Nishiyama geothermal power plant in Fukushima for three years and eight months to confirm its effectiveness.	From 1984, NEDO and others tested it in Hijiori, Yamagata Prefecture, and from 1989, CRIEPI and others tested it in Ogatsu, Akita Prefecture.	The coaxial double tube wasdemonstrated in H3 by the former Institute of Environmental Science and Technology at 370 kW. The multilateral is being demonstrated in Germany.	NEDO is conducting research and studies. Conducting resource assessment at four promising areas.	Basic research stage by JOGMEC.



Source: https://www.enecho.meti.go.jp/category/resources_and_fuel/geothermal/nextgeneration/data/1_4.pdf

We will describe the main technical challenges for each type of "next-generation" geothermal power, although this is not an exhaustive list.

(1) EGS

Enhanced Geothermal System ("EGS") is a method of artificially cracking rock, as shown in the diagram above. Groundwater will then be either injected into the cracks or induced from the underground to circulate the hot water around the cracks[1]. However, in Japan

1 Conventional geothermal power generation differs from EGS, in that it involves extracting steam or hot water from areas that already have natural fissures.

earthquakes occur frequently. Thus, artificial cracks tend to close quickly due to stress[2]. In addition, for the purpose of EGS, the artificial cracks must be inserted precisely toward the heat source, which technology is still under development as per our understanding. We understand that some advanced demonstration tests for EGS is underway, particularly in the United States[3].

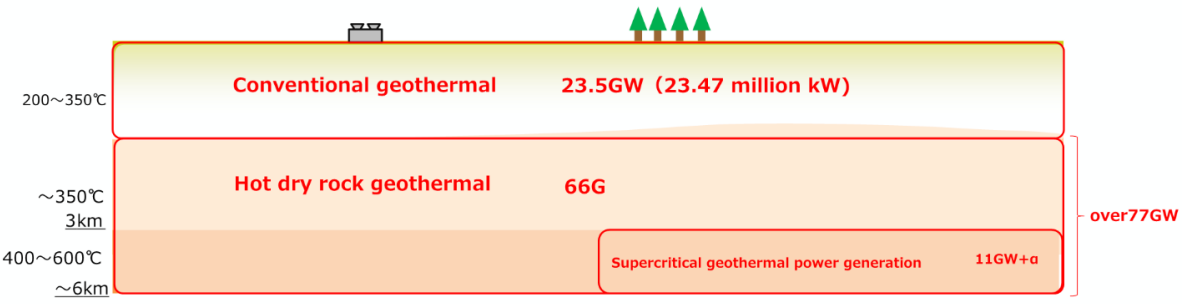
(2) Closed-loop

Closed-loop geothermal power generation differs from the conventional geothermal power generation, and also from EGS, in that it does not rely on any discovery of geothermal reservoirs, in the first place. In closed-loop system, the heat is to be sourced by artificially injecting a fluid (i.e., water) into a specific heat source, and then circulating such water within or near the heat source, roughly speaking. However, here is a technical bottleneck in this system. Unlike metals, a rock has low thermal conductivity, and thereby during the water circulation process, the rock itself naturally cools down, resulting it technically difficult to extract sufficient steam from the source. As to a public source, Chubu Electric Power is participating in research and development project of closed-loop geothermal in Germany.

(3) Supercritical Geothermal Energy

It looks that this system has great potential among the "next-generation" geothermal . As being in a supercritical state of water, it has the advantage of utilizing the characteristics of water vapor, which causes less friction than water in liquid status, while maintaining the thermal efficiency which is more advantageous than water vapor (in gaseous status).

Reference:Image of Japan's "Next-Generation" Geothermal Potential



Source: https://www.enecho.meti.go.jp/category/resources_and_fuel/geothermal/nextgeneration/data/1_4.pdf

As shown in the chart above, the bottleneck for this supercritical geothermal power generation is that the heat source is located at a depth of approximately five to six

2 On the other hand, it is said that there may be places in other countries where the geology and terrain are different from those in Japan, where EGS may be suitable.

3 https://www.energy.gov/eere/geothermal/enhanced-geothermal-systems-egs-pilot-demonstrations etc

kilometers. Moreover, the temperature is relatively high (approx. 500 degrees), which makes it difficult to conduct the drilling work at such a depth if using the conventional drilling technologies (i.e., those used for oil and gas). In addition, it is said that the heat source near magma is highly acidic, which makes it difficult to maintain the metallic pipes. We understand that the New Zealand government is currently conducting a demonstration project for supercritical geothermal power[4].

(4) Carbon-recycled Geothermal Power Generation

Carbon-recycled geothermal power generation sources the heat by injecting carbon dioxide (CO2) into underground, instead of water, by utilizing CCS technology. CCS technology is still under development in Japan as well. It looks that carbon-recycled geothermal power generation has some potential, if the commercial use of CCS technology is realized in the future.

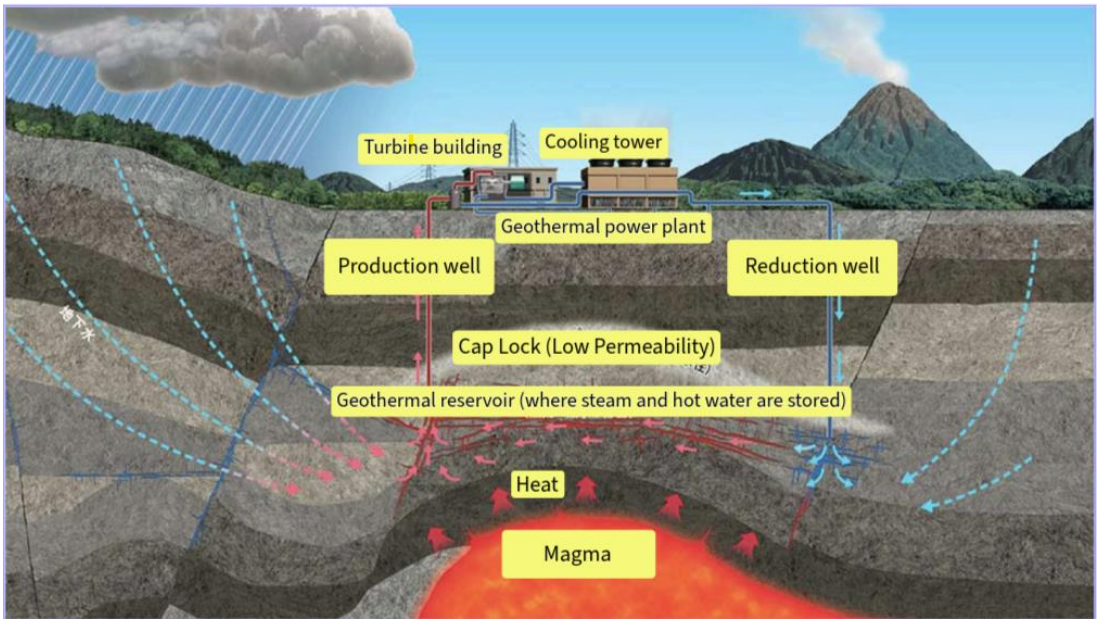
3. Some thoughts over application of the Hot Springs Act of Japan to "next-generation" geothermal

We have described our understanding of the main types of the "next-generation" geothermal power generation and their respective technical challenges. Finally, we will briefly discuss the applicability of the Hot Springs Act, one of the main regulations as applicable to geothermal power generation in Japan, to the "next-generation" types of geothermal power generation.

Article 3 of the Hot Springs Act stipulates that any person who intends to "excavate" the surface land for the purpose of leaking out the hot springs from underground must obtain license by the relevant prefectural governor.

The term "hot spring" as used in the Hot Springs Act refers to some hot water, mineral water, steam, and other gases that are sourced from the earth, which have the temperature or substance as specified in the Hot Spring Act. For this reason, conventional (i.e., other than the "next-generation" types) geothermal power generation projects are almost always subject to this regulation under the Act. Specifically, conventional type of geothermal power generation projects always rely on the underground water that has accumulated in the caprock and has been heated by magma (it is called as "geothermal reservoir"). Under the conventional type of geothermal projects, the steam and hot water are to be extracted from this "geothermal reservoir" by drilling the wells from the surface (please see the figure below).

4 https://www.beehive.govt.nz/release/government-gaining-ground-pursuit-supercritical-geothermal-energy



Source: https://www.jogmec.go.jp/publish/plus_vol13.html

This is why any conventional geothermal power generation project falls under the activities as regulated under Article 3 of the Hot Springs Act (described above), and thereby, the operator must obtain the license from the prefectural governor thereunder.

On the other hand, it is highly likely that the provision of the Hot Springs Act as applicable to the conventional geothermal power generation will not directly apply to the "next-generation" types of geothermal power generation. The following is our personal thought on this point, i.e., the applicability of the regulation under the Hot Spring Act to the "next-generation" types of geothermal[5].

First, EGS is a system in which artificial cracks are created in rock and groundwater is to be circulated around these artificial cracks, by either injection or induction from the ground, and then steam is extracted therefrom. Although this is arguable, judging from the fact of EGS to "artificially" inject groundwater into the "artificially" created cracks underground, we are of the view that EGS does not directly fall under the "excavating" the surface land for the purpose of "leaking out" hot springs as defined in Article 3 of the Hot Springs Act.

Next, we mention the closed-loop type of geothermal. Although it is still arguable, it is likely that the Hot Springs Act does not directly apply to the closed-loop type, given that it does not envisage any activity of "excavating" the surface land for the purpose of "leaking out" hot springs, like EGS.

5 "Next-generation" geothermal power generation is still under development, and it is not yet in a phase of practical use not only in Japan but also in other countries. Therefore, at least in Japan, there are no concluded interpretations, court decisions, or public authority's interpretations of the applicable laws, including the Hot Springs Act, in the context of "next generation" types of geothermal.

Third is the supercritical geothermal. Although it can theoretically be subject to the regulation under the Hot Springs Act, it is difficult to apply this regulation to supercritical geothermal, given that its target heat source is situated in very deeper underground than conventional geothermal power generation. The Hot Spring Act does not suppose any excavation activities in such deeper location at all.

Finally, carbon-recycled geothermal power generation does not use water or steam in the first place. Thus, it is unlikely to be subject to the regulation under the Hot Springs Act.

- This newsletter is published as a general service to clients and friends and does not constitute legal advice. Should you wish to receive further information or advice, please contact the author[s] as follows:

- Author:
Yoshiaki Otsuki (yoshiaki.otsuki@amt-law.com)

- If you wish to unsubscribe from future publications, kindly contact us at General Inquiry.

- The back issues of the newsletter are available here.