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How Japan can Treble Growth in Geothermal Power - A Study Focusing on the Importance of the Local Community in Comparison with Success in New Zealand

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ABSTRACT

Japan has the third largest geothermal energy potential in the world, behind only the United States and Indonesia. However, the installed geothermal power generation capacity is far behind the two countries and has remained at 500 MWe for decades. After the earthquake in 2011 and Fukushima crisis, the Japanese government is making efforts to increase renewable energy including geothermal power, with a target to triple the capacity of geothermal power generation by 2030. Despite efforts, as of January 2019 the capacity has not increased more significantly than the original 500 MW.

On the other hand, in New Zealand, the geothermal power generation capacity was 435 MW in 2005, similar capacity as Japan during that time. However, capacity was increased to 762 MW in 2010 and 1005 MW in 2015; doubling over the course of 10 years. This includes developments of larger power plants such as Nga Awa Purua, Ngatamariki, and Mokai which includes a joint venture with the local community.

In contrast, there are several cases in Japan where the local community has objected against geothermal development causing projects to be shut down. Towns against geothermal development include, Minamiizu Town, Tsumagoi Village, Toyoha in Hokkaido, and the Lake Akan area, etc. This study includes consideration on how Japan can treble growth in Geothermal Power, by focusing on collaboration with local community by referring to the success in New Zealand from a business, economic and social impact standpoint.

1. INTRODUCTION

The New Zealand Embassy in Japan organized and facilitated a roundtable meeting between a Maori representative from New Zealand, the Ainu, and the Lake Akan community at Kushiro City in Hokkaido, Japan on April 2019. The purpose of the meeting was to explore potential cooperation and tourism opportunities for Maori business in Lake Akan. I participated this as a member of New Zealand Trade & Enterprise as I was interested in observing progress for geothermal development through collaboration with local community.

27 years ago, on March 1992, New Energy and Industrial Technology Development Organization (NEDO) of Japan conducted a large-scale survey for geothermal potential. The study concluded the existence of high potential of geothermal resources. In the report on the 1,132th page, On page 1,132 of the subsequent report, which serves as a summary of the survey, it is stated that a steam dominated geothermal resource is expected to be present in the subsurface. As of today, unfortunately, the development has not proceeded. Local government does not agree with geothermal development due to a concern of negative affects on natural resources.

The NZ / Ainu roundtable highlighted an opportunity for a New Zealand Maori company to establish a partnership with the Japanese community. Post roundtable, there was a Kapa Haka performance by Maori, in addition all the participants enjoyed an Ainu performance at the Ainu Theatre, Ikor. It was a successful occasion where both parties were educated on not just the differences, but the similarities of both countries, communities, and the indigenous people.

I observe the stagnation of geothermal development here represents many other problems of geothermal developments around Japan, and I expect the initiative taken by the New Zealand Embassy in Japan possibly be a hint to solve those similar issues laid on those development.

In New Zealand, there were objections against developments of geothermal power stations by local indigenous people as well. However the conflicts were resolved and the government was able to develop 1,005 MWe of geothermal power capacity, which is twice as much as Japanese. Understanding how the New Zealand government overcame protest for geothermal development can serve as an example for the Japanese to be able develop geothermal power and increase capacity.

Despite the similarities, it is not a simple comparison between Japan and New Zealand. The social status of standing points for Maori in New Zealand and Ainu in Japan are different, in addition, it is not only indigenous people that object geothermal development in Japan, others include local hot spring owners and businesses. Understanding these complications, Japan wants to create solutions and use examples to grow geothermal capacity in Japan.

Figure 1: New Zealand Maori Performance in Hokkaido

2. HISOTORY OF GEOTHERMAL DEVELOPMENT IN JAPAN AND NEW ZEALAND

Like Japan, New Zealand sits above the Pacific Ring of Fire. Running beneath its slender islands, the Indo-Australian and Pacific Plates generate an abundant supply of geothermal energy potential. It is no surprise that New Zealand has long been a leader in renewable energy innovation, especially in geothermal energy.

New Zealand's commitment to harnessing geothermal energy stems as far back as 61 years, in 1958 a geothermal plant was opened in Wairakei. At that time, it was only the second-ever commercial geothermal plant in the world, and the first to utilize flash steam from geothermal water as the energy source to generate electricity. In the early 20th century in 1911, the world's first commercial geothermal power plant was built in Larderello, in the province of Pisa in Italy. However, no new geothermal power stations had been successfully built since 1958. A majority of geothermal wells in Japan and New Zealand are water dominant wells, while Larderello is steam dominated. Since hot water coming from the wells into the turbine at the power stations damage fans of turbine, it took almost half a century before the first water dominated geothermal power station came online. New Zealand was the first to develop steam-water separator in order to overcome this issue. The success at Wairakei encouraged other geothermal developers and that accelerated other developments in the world including Japan. (Tosha. T 2012).

Today, 80% of New Zealand's electricity comes from renewable resources. New Zealand is committed to raise this capability to 90 percent by 2025 through innovation such as reducing energy usage and local power generation. New Zealand also has a long history of partnering with other countries to provide innovative assistance and advanced technology.

Year	Country	Historic Event
1958	New Zealand	Invention of steam-water separator and commercial launch of geothermal power station for water dominated wells at Wairakei Power Station
1966	Japan	The first Japanese geothermal power station was built at Matsukawa in Iwate prefecture by a private developer named Japan Metals & Chemicals Co., Ltd.
1967	Japan	The second geothermal power station named Odake Power Station was build in Kyushu by Kyushu Electric Power Co., Inc. It was 11000kW output capacity with single flash type using steam-water separator.
1991	New Zealand	Resource Management Act 1991 became into force.
1999	Japan	Started operation of Hachijyojima Geothermal Power Station by TEPCO – Tokyo Electric Power Company in March 1999. (3,300kW capacity, Flash type, 2 x production wells (1,650 meter & 960 meter depth, 1 x 100 meter injection well) This is the last development for the next 20 years in Japan for larger power geothermal power stations with flash type facility and combination of two wells by production and injection.
2007	New Zealand	Mokai 1B has completed to build and installed 17 MWe capacity, followed by Mokai 1A (55 MWe) in 1999 and Mokai 2 (39 MW) in 2005. With this completion, Total installed capacity of Mokai Geothermal Power station owned by Tuaropaki Trust and Mercury became 111 MWe.
2010	New Zealand	Nga Awa Purua Power Station constructed by a joint venture of Japanese Sumitomo Corporation, Fuji Electric, and New Zealand Hawkins started its operation with 144 MWe installed capacity.
2013	New Zealand	Ngatamariki Power Station started its operation with 82 MWe installed capacity with Oramat's binary system.
2014	New Zealand	With the completion of Te Mihi plants with 166 MWe installed capacity, the summation of installed geothermal generation capacity exceeded 1,000 MWe.
2019	Japan	7 MWe geothermal power station at Matsuo Hachimantai in Iwate prefecture started its operation at the first time in 20 years for this kind of power station.

Figure 2: History of geothermal developments in Japan and New Zealand

Figure 3 shows the Geothermal Annual Electricity Generation for Japan and New Zealand respectively. New Zealand, the inventor of the flash separator, is eight years ahead of the Japanese development for such a geothermal plant. Both countries' electricity generation were at similar levels, approximately 1,000-2,000 GWh per annum in 1980s, however there was a time when Japan exceeded New Zealand in 1990s. However, Japanese geothermal development halted after the launch of the Hachijyojima Geothermal Power Station by the Tokyo Electric Power Company in March 1999. Since then, there has not been any new geothermal power stations, with the exception of smaller binary plants which use Onsen hot springs, this caused a significant stagnation of geothermal industry in Japan until 2019. In comparison, in New Zealand, over NZ$2 billion was spent adding some 500 MW of new geothermal plants since 2008 and it is now 20% of New Zealand annual electricity generation. The different choices of the two countries caused Japan to generate just 2,559 GWh in 2015 while New Zealand reached a record of 7,411 GWh in 2015.

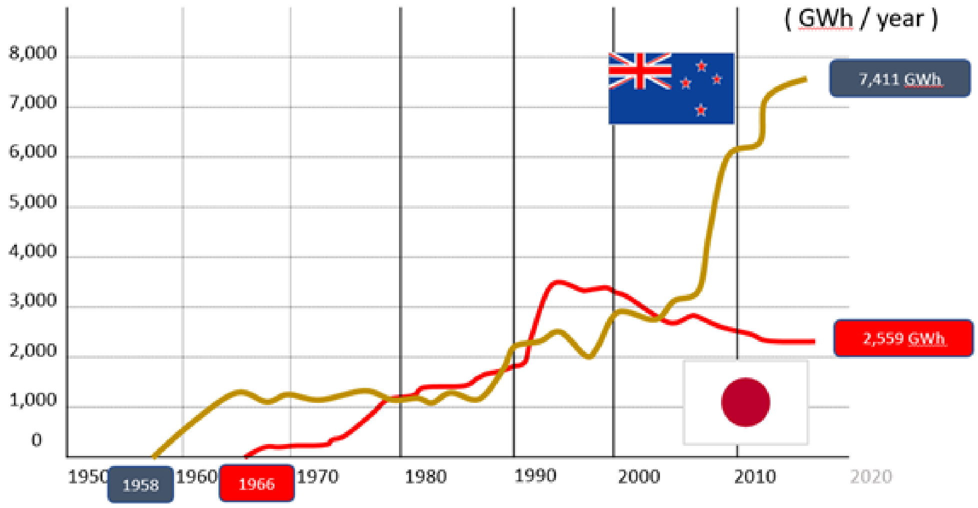


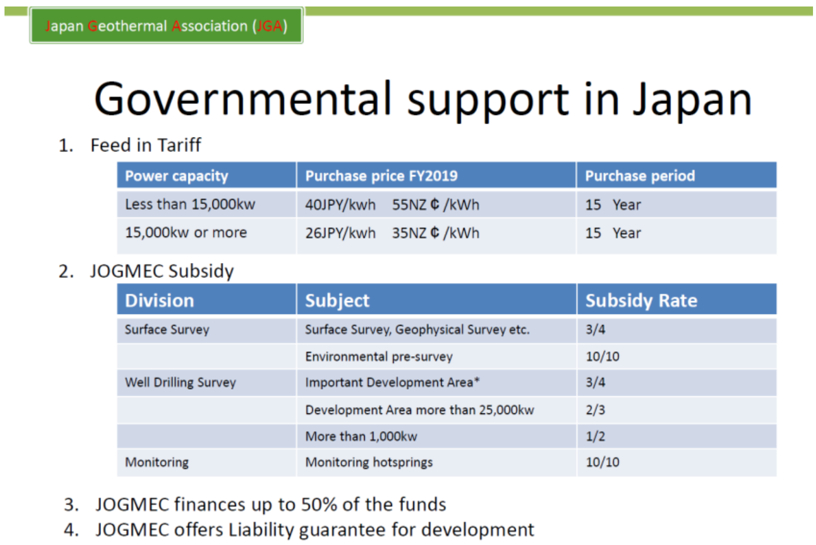
Figure 3: Geothermal Annual Electricity Generation in New Zealand and Japan

3. GEOTHERMAL DEVELOPMENTS IN JAPAN

3.1 Rapid movements after the Great East Japan Earthquake in 2011

As mentioned above, geothermal development in Japan was stagnated, but after the Great East Japan Earthquake, renewable energy became a new focus. After the earthquake, all 60 Japanese nuclear reactors were shut down, and the nuclear power generation capacity, which accounted for 26% of the total before the earthquake, went to zero. Although emergency alternative power sources were implemented, they are all fossil fuel sources such as LNG, oil, and coal. Due to this crisis the Japanese government has rapidly launched measures to increase its renewable energy capacity. They have set up industrial development policies such as a feed in tariff system, for new energy sources such as solar, wind, biomass and geothermal, as well as subsidies for development. Regarding geothermal, in addition to the establishment of government funds and a subsidy system by JOGMEC under the Ministry of Economy, Trade and Industry, funds were invested for the development of geothermal development technology by NEDO and JOGMEC, also under the Ministry of Economy, Trade and Industry (Figure 4).

As a result, in the six years from fiscal-year 2012 to fiscal-year 2018, 70 development areas were subsidized for the surveying of geothermal development. In July 2019, two new geothermal power plants become operational for the first time in 20 years. As shown in Figure 5, development of the new geothermal power plants, by multiple operating companies and local governments, is still ongoing in many places. Based on Japan's energy policy (Basic Energy Policy), the amount of electricity derived from geothermal power generation in the fiscal-2030 year ,is to be nearly tripled from approximately 0.3% to 1.0 to 1.1%. In the Basic Energy Policy, it is also proposed that renewable energy is to be the main power source by 2050. With these goals in mind, Japan will continue to develop geothermal power plants, and it is expected that the industry will be increasingly active.


Japan Geothermal Association (JGA)

Governmental support in Japan

1. Feed in Tariff

Power capacity	Purchase price FY2019	Purchase period
Less than 15,000kw	40JPY/kwh 55NZ¢/kWh	15 Year
15,000kw or more	26JPY/kwh 35NZ¢/kWh	15 Year

2. JOGMEC Subsidy

Division	Subject	Subsidy Rate
Surface Survey	Surface Survey, Geophysical Survey etc.	3/4
	Environmental pre-survey	10/10
Well Drilling Survey	Important Development Area*	3/4
	Development Area more than 25,000kw	2/3
	More than 1,000kw	1/2
Monitoring	Monitoring hotsprings	10/10

3. JOGMEC finances up to 50% of the funds
4. JOGMEC offers Liability guarantee for development

Figure 4: Government support in Japan (Source: Japan Geothermal Association - JGA November 2018)

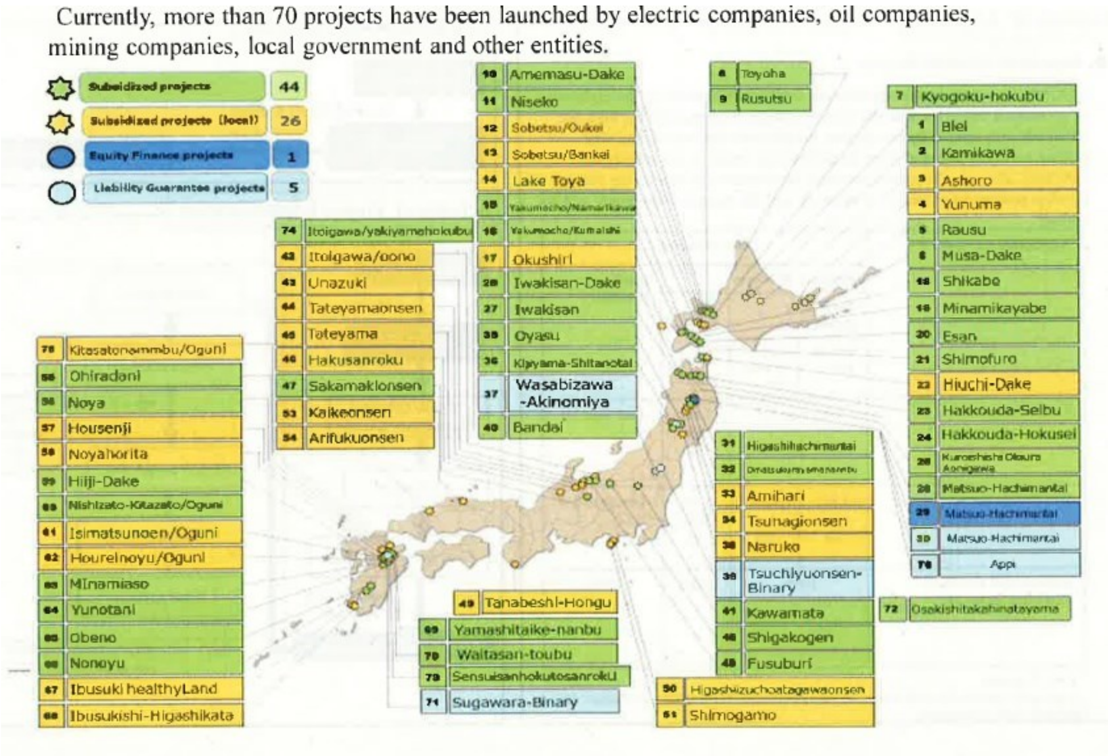


Figure 5: More than 70 projects supported by JOGMEC (Source: JOGMEC Geothermal Unit June 2019)

3.2 Challenges for Expanding Geothermal Power Generation in Japan

The Japanese efforts to increase geothermal development that has been implemented all over Japan, and is steadily moving toward the overall energy goals of the Japanese government. I would like to express my deep respect to those involved in solving various issues toward this goal, and in particular to the members of the JOGMEC Geothermal Unit as a policy enforcement body of the Japanese government. In consideration, the goal of increasing the amount of geothermal power generation by 3 times by fiscal-year 2030 based on the basic energy policy, I doubt its feasibility. A reason for doubt, is that approximately six years have passed since the start of the systems in 2012, and finally two large geothermal power plants have been started earlier this year. Actually, it has been reported that it will take 10 years or more from the start of the survey to open a geothermal power plant in Japan. Assuming that the establishment of a new geothermal power plant following these is announced every year, will a power plant three times as large as the present scale be installed in the next 11 years?

In Japan, the total of all geothermal power plant capacity is 500 MW. The Matsukawa Geothermal Power Plant opened in 1966, at the time the annual increase was around 15 MW. However, the target will not be achieved unless new geothermal power plants rated at ~100 MW capacity needs to be built annually to enable an increase to 1,000 MW in the next 11 years. This is about 6 to 7 times faster than the former 15 MW a year. It is a simple calculation, but the average power output of the existing geothermal power plant is approximately 25 MW. In order to successfully reach the overall goal the following would need to occur, JOGMEC receives a grant and conducts underground surveys, all 70 sites successfully started power generation, and each would start generating around 25 MW, exceeding the target value at 1,750 MW. In order to achieve 1,000 MW at an average 25 MW power plant, at least 40 sites must be successfully developed (that is, the probability of success is closer to 60% or below) and about four new geothermal power plants must be completed each year. I have not heard that the establishment of successful underground research in Japan and progressing to actual development is such high. In addition, I have heard that the development of geothermal power plants depends on the support measures such as subsidies from the Japanese government, such as the Sunshine Project, at the time when the national budget was mostly invested for the development of geothermal power plants (Figure 6) In other words, there is not 6 to 7 times as many support measures as in 1974-1997. We can see a certain movement to achieve the goal by 2030, but it is inevitable that there will be many challenges in the way to achieve it.

List of Geothermal Power Plants in Japan (in order of output)

Power Plant	Output	Location (prefecture)	Operator
Hatchobaru Geothermal Power Plant	112.0MW	Oita	Kyushu Electric Power
Kakkonda Geothermal Power Plant	80.0MW	Iwate	Tohoku Electric Power
Sumikawa Geothermal Power Plant	50.0MW	Akita	Tohoku Electric Power
Ogiri Geothermal Power Plant	30.0MW	Kagoshima	Kyushu Electric Power
Yanaizu-Nishiyama Geothermal Power Plant	30.0MW	Fukushima	Tohoku Electric Power
Uenotai Geothermal Power Plant	28.8MW	Akita	Tohoku Electric Power
Takigami Geothermal Power Plant	27.5MW	Oita	Kyushu Electric Power
Yamagawa Geothermal Power Plant	26.2MW	Kagoshima	Kyushu Electric Power
Mori Geothermal Power Plant	25.0MW	Hokkaido	Hokkaido Electric Power
Matsukawa Geothermal Power Plant	23.5MW	Iwate	Tohoku Sustainable & Renewable Energy
Onikobe Geothermal Power Plant	15.0MW	Miyagi	J-POWER
Otake Geothermal Power Plant	12.5MW	Oita	Kyushu Electric Power
Onuma Geothermal Power Plant	9.5MW	Akita	Mitsubishi Materials
Takigami Binary Geothermal Power Plant	5.1MW	Oita	Idemitsu Oita Geothermal
Sugawara Binary Geothermal Power Plant	5.0MW	Oita	Kyuden Mirai Energy
Hachijojima Geothermal Power Plant	3.3MW	Tokyo	Tokyo Electric Power
Waita Geothermal Power Plant	2.0MW	Kumamoto	Waita-kai
Suginoi Geothermal Power Plant	1.9MW	Oita	Suginoi Hotel Co., Inc.
Medipolis Ibusuki Power Plant (geothermal binary power generation)	1.5MW	Kagoshima	Medipolis Energy

Figure 6: List of geothermal power plants in Japan (Source: JETRO October 2017)

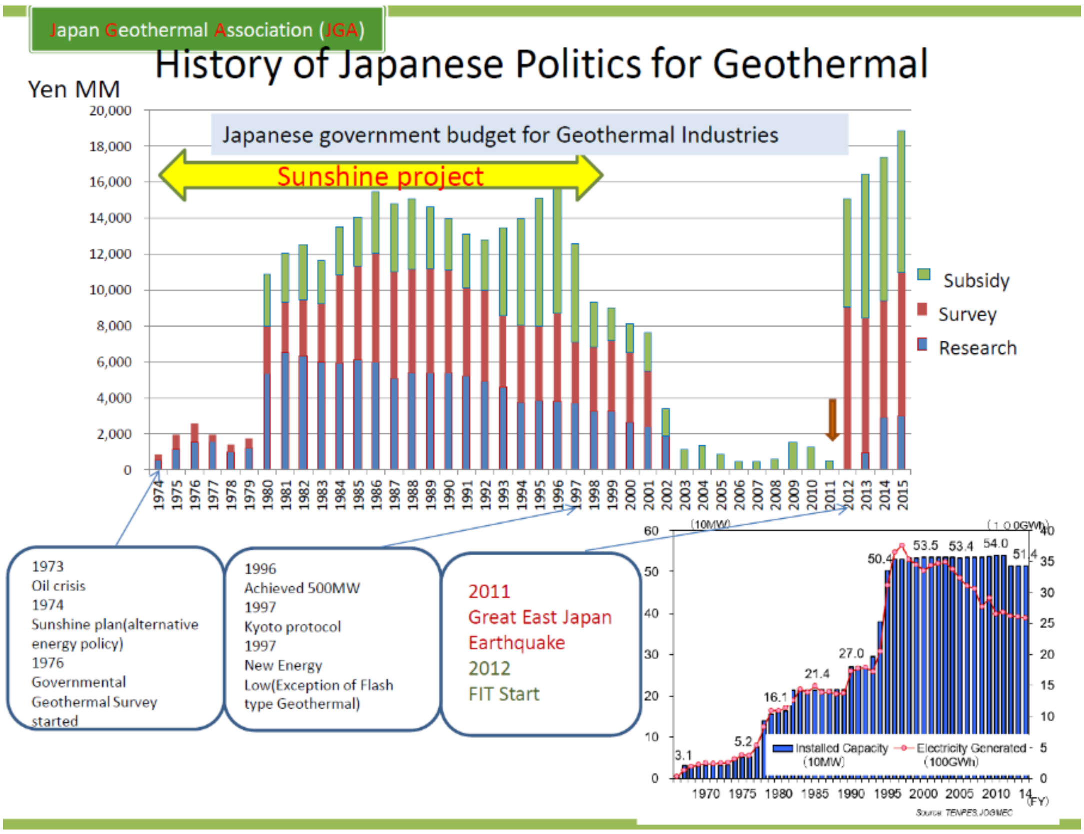


Figure 7: History of Japanese Politics for Geothermal (Source: Japan Geothermal Association - JGA November 2018)

I understand that Japan's geothermal personnel have made extraordinary efforts in the process leading up to here. I think that there is much progress in solving the issue of national parks property. There is also the establishment of a system for the introduction of the feed-in-tariff after the Tohoku earthquake of 2011 and the establishment of a subsidy system. As a result of the legal system reform in 2012, 32.9% of land from national parks, where geothermal power which can be used for generation, can now be developed. This seems to have greatly increased the number of geothermal development bases.

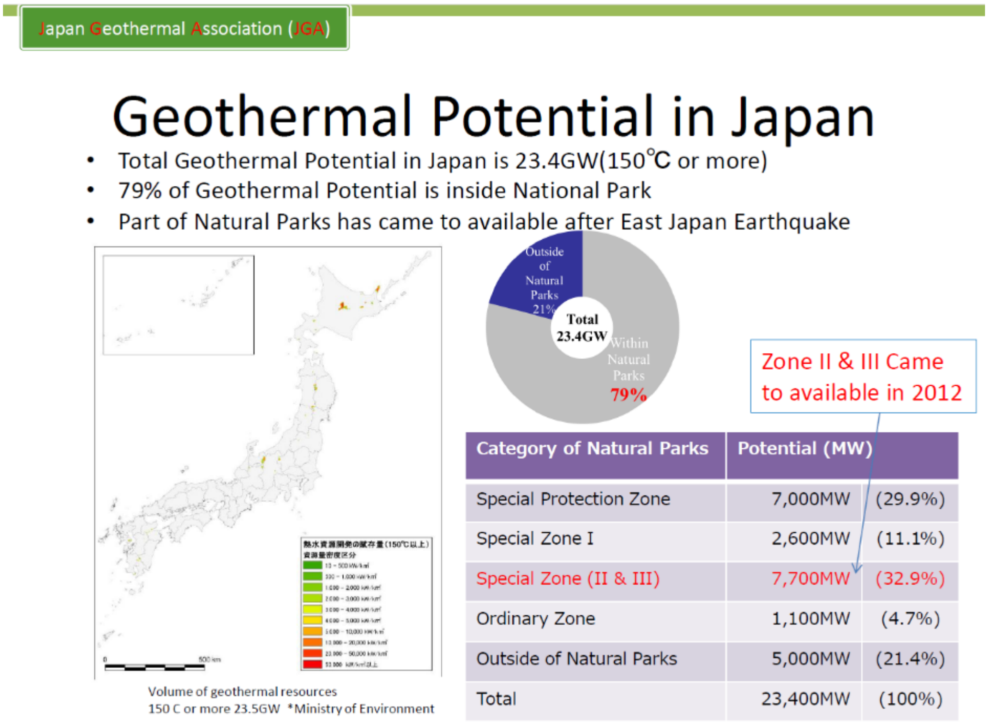


Figure 8: Geothermal Potential in Japan (Source: Japan Geothermal Association - JGA November 2018)

3.3 Locations where people are against geothermal development in Japan

While the implementation of various support measures and the revision of the legal system is progress, there are also many opposing views over geothermal power generation. According to Uechi, "In older times from the 1980s, at least nine regions by 2010 have been confirmed by hot spring (Onsen) operators as involved in movements against regional power generation." (Figure 9)

Year	Location	Prefecture	Development project
1981	Kusatsu - Tsumagoi	Gunma	Shirane sanroku (Kusatsu town, Tsumagoi village)
1981	Beppu	Oita	Garandake (Beppu city, Yufu city)
1983	Shuzenji	Shizuoka	Izu city
1983	Gero	Nagano	Otaki village
1989	Oguni	Kumamoto	Oguni town
1992	Hachimantai	Akita	Kazuno city
1996	Toyoha Jyozankei	Hokkaido	Sapporo city
2002	Kirishima	Kagoshima	Kirishima city
2004	Obama – Unzen	Nagasaki	Unzen city
2007	Ibusuki	Kagoshima	Ibusuki city
2008	Kusatsu Tsumagoi	Gunma	Tsumagoi village

Figure 9: Opposition movement over geothermal development identified by 2010（J. Uechi 2010）

In response to these opposition movements, Uechi cited the following four factors leading to the occurrence of conflict. The first, there is a shortage of information, knowledge, and experience to predict and assess the impact of underground development. The second is communication failure. From the beginning of the project, the developers themselves did not have any open communication with the residents themselves, and as a result an opposition movement was created. The third, Onsen owners have negative impressions of geothermal development while there is no such risk in practice. Lastly, the lack of benefits and uncertainty levels for geothermal development are raised.

At present, local understanding is a major premise in order to receive JOGMEC's support, and it seems that cases of “communication failure” pointed out by Uechi is decreasing. Not only the locations listed in Figure 9 but also where local residents are opposed to geothermal development, there are areas with a high amount of geothermal potential, it is highly desirable to improve relationships in the future.

4. GEOTHERMAL DEVELOPMENT AND COMMUNITY IN NEW ZEALAND

New Zealand has 1,005 MW of geothermal power plant installed capacity as of July 2019, and geothermal power supplies about 17% of electricity in New Zealand as a whole. Development since the establishment of the Wairakei Geothermal Power Station in 1958, especially after the enforcement of the Resource Management Act in 1991, is remarkable. Large-scale geothermal power generation began with the construction of the Mokai Geothermal Power Station in 2007. The current construction has reached the current capacity is as described in Section 2 of this paper.

With New Zealand Trade & Enterprise, there was a conducted a tour of New Zealand Geothermal Fields where 23 Japanese geothermal developers in July 2019 visited Wairakei Geothermal Field and Rotokawa Geothermal Field. In particular, the Rotokawa Geothermal Field, two power plants were visited, the Nga Awa Prurua Geothermal Power Station and the Ngatamariki Geothermal Power Station.

Figure 10: Japanese delegation visited Nga Awa Purua Power Station in July 2019

The field visitors from Japan found a great inspiration for geothermal development in Japan from New Zealand. Especially in the Rotokawa Geothermal Field. The three power plants installed in the field, we only visited two, are a joint venture between the Maori Trust (Tauhara North No. 2 Trust - TN2T) which represent the local community and the electric power company, Mercury. In addition to the familiar Mercury logo, the TN2T logo, which looks like a symbolizing Maori, welcomed us. According to McLoughlin K. et al (2010), TN2T has 50% ownership of Rotokawa A's land and steamfield, and approximately NZ $ 700,000 is paid annually for TN2T as a royalty without risk. In addition, the process from the development decision of Nga Awa Purua following Rotokawa A to the start of production is very interesting. Like Rotokawa A, in Nga Awa Purua, a royalty is also paid. But the large initial cost of geothermal development was taken on by the developer Mercury, and along with royalty payments, the share of TN2T increased from 35% to 50%. Also, while partner company Mercury (then Mighty River Power) is knowledgeable on geothermal developments, TN2T contracts with Sinclair Knight Mertz – SKM, now Jacobs, by doing this, they were able to understand and express appropriate opinions with scientific and technological knowledge for operations done by Mercury.

These matters are all very interesting because they wipe out all four factors leading to the occurrence of the dispute mentioned by Uechi in the previous section. That is, TN2T as local community side has obtained sufficient information for making decision on geothermal development by actively contracting with experts. First, communication failure cannot occur because local communities themselves are involved in geothermal development. Also, local communities have received the full benefits for geothermal development by being paid a royalty on land use. In this regard, it seems that the system has become a consistent and functioning system because no risk occurs, and it is ensured that it is paid annually.

New Zealand's geothermal development was initially promoted by the New Zealand government led by Wairakei and Ohaaki, but since the subsequent development of Rotokawa, the local Maori Trust has always been involved in geothermal development. There are regions such as Mokai, Ngawha, and Kawerau that have all been successfully developed.

Another point we noticed during our visit to the geothermal fields in July 2019 is international cooperation. The Nga Awa Purua Power Station, owned and operated by both TN2T and Mercury, contains a photo. As a proof of the cooperation of Japanese and New Zealand companies (Sumitomo Corporation, Fuji Electric, and Hawkins) involved in project management and actual construction of the power plant. As a conclusion of this section, I would like to include that there was international cooperation, in addition to the fact that the success of geothermal development in New Zealand is closely linked with the local community.

5. CONCLUSION

As I have discussed as the above, geothermal development in Japan appears to be heating up again after a period of stagnation. In fact, in addition to JOGMEC's 70 development subsidies, I also know some companies that are working on a number of projects to survey and explore underground to search geothermal resources without resorting to government subsidies claiming they are slow progress. In the future, development and construction of geothermal power plant facilities will be prompted in many sites in Japan. However, there are a lot of challenges for achieving the overall goal, and it is expected that the efforts of associated parties will continue. At this time, if I define scientific methods for analysis of reservoirs, technology for drilling into reservoirs, and construction of power plants, etc. as a hard and tangible aspect, the laws and regulations set forth by the Japanese and local governments for opening of geothermal power stations, the creation of a system, and partnership with the local community will help to deepen the understanding of the geothermal power to the local residents as soft and cultural/intangible aspect, there should be meaningful actions in the future on the "soft" side. I believe actions on cultural understanding and working together with local community are essential actions for the successful future of the geothermal industry in Japan.

Also, in Japan, the problem of national parks seems to be solved but the opposition against development by hot spring /onsen owners are persistent. Of course, there is a Japanese way in Japan, and I do not think that the methods that have been successful in New Zealand are applicable in Japan, however I do believe it is useful knowledge. Until now, hard cooperation as my definition has only just begun through partnerships with JOGMEC, but from now on, more soft and social cooperation can be focused and implemented. I expect organizations such as New Zealand companies can contribute much to Japan's geothermal development by working together.

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