Research Report

Investigating Stakeholder Perspectives on Development of Hot Spring Power Generation

A Case Study of Beppu City, Oita Prefecture, Japan

BY

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Certification Page

I, Pham Thanh Ha (Student ID 51217623) hereby declare that the contents of this Research Report are original and true and have not been submitted at any other university or educational institution for the award of degree or diploma.

All the information derived from other published or unpublished sources has been cited and acknowledged appropriately.

PHAM, THANH HA

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Summary

In Japan, energy has become a pressing concern, especially after the double natural disaster of March 2011. As part of the policy to increase Japan's energy security, the government has made efforts to develop renewable energy. Geothermal is among the energy sources incentivized, as Japan possesses one of the world's largest geothermal energy potential. One method of utilizing geothermal is conversion to electricity via hot spring power generation, or *onsen hatsuden* in Japanese. *Onsen hatsuden* differs from conventional flash or steam type geothermal power plant in its usage of binary cycle power generation, which uses geothermal heat to transform a secondary working fluid into steam turning turbines and generating electricity. This method can be used for lower temperature wells, which is not possible with other types of geothermal power generation.

Despite efforts to increase renewable energy share in Japan, development of *onsen hatsuden* and geothermal power generation in general has been rather stagnant in the last few years, with little change in national installed capacity from 2010 to 2017. Development of geothermal energy faces a range of challenges, including investment cost and criticism from local residents and hot spring business owners, because geothermal energy also uses the same resource - hot spring water. *Onsen hatsuden* promises that with its technology, the *onsen* source would not be adversely impacted and at the same time value added to the region. In order to further develop this renewable energy, it is important to understand what some of the perspective of *onsen hatsuden* shared by stakeholders could be. This research aimed to tackle that question through a case study of Yuuyama Geothermal power plant, an *onsen hatsuden* power generation plant built in Beppu, Oita Prefecture, Japan in 2014.

Q methodology was used to identify stakeholders' perspectives on *onsen hatsuden*. This comprised a multistage method of research that uses factor analysis of rankings of qualitative statements to identify and understand the range of social perspectives that exist on the topic. This method involved 11 participants who were directly involved in the process of decision making and building the Yuuyama powerplant.

The results of Q methodology yielded 3 main perspectives on *onsen hatsuden* in the case of Yuuyama. First, there were stakeholders who were proponents of *onsen hatsuden*, recognizing the need for more renewable energy in Japan as well as seeing this as an opportunity to revitalize the local area. Secondly, there were stakeholders who are not the biggest supporters of *onsen hatsuden* and would readily put a stop to a project if they perceive a threat from the project. Finally, there are stakeholders who were more neutral or even expressed criticism of the political apparatus and decision-making process. Considering the influence that stakeholders have on the development of *onsen hatsuden*, the three identified perspectives serve as a point of reference for policy makers and investors in binary geothermal power to improve communication efficiency among all stakeholders and in particular with local residents.

I. Introduction

There are two trends that define the current energy market in the world. Firstly, energy / electricity consumption has been on a rapid rise, with a likely chance of demand for energy creating capital requirements surpassing governments' capability to supply (Dincer, 2014, Wahid, 2016, Enerdata, 2017). Secondly, the environment degradation concerns over production of energy / electricity has gained more attention from policy makers, catalyzing the movement towards increasing energy efficiency and renewable energy sources (Jenniches, 2018). In addition to the global trends, the event of March 11th when the Tohoku Great Earthquake followed by the incident at Fukushima nuclear power plant has greatly altered Japan's outlook on energy security and energy generation. The incident prompted the government to shutdown most of its nuclear power reactors, creating a shortage of domestic electricity production and causing electricity price to continuously increase (Figure 1).

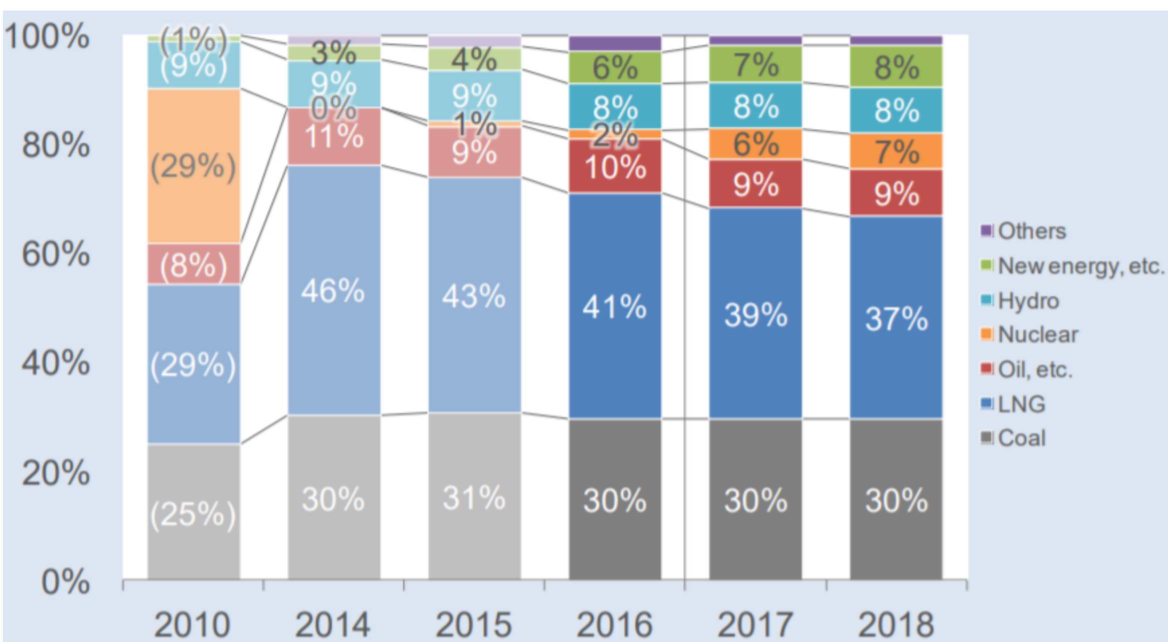


Figure 1 Changes in Japanese Electric utilities power mix

Source: IEEJ, 2017

To make up for the loss of power generation from nuclear, Japan had to rely on liquid natural gas, coal and oil, drastically increasing their share from fossil fuel to over 80% in the power generation mix in the following years. Recognizing that import of fossil fuels is not the optimal solution to the energy problem, Japan has turned to other solution. Despite protest from local residents, their first move was to restart a cumulative of 10 reactors by the end of FY 2018 (IEEJ, 2017). Japan are also in the process of increasing their renewable energy generation source, which was reported to be 17.4% in 2018 (ISEP, 2019). This ratio is relatively low when compared to other OECD countries, ranking 16th overall in the world (Ministry of Economy, Trade and Industry, 2016). Understanding the role renewable energy plays in providing energy security and mitigating climate change, Japan has looked to increase this ratio to 20~22% by 2030 (Japan for Sustainability, 2017). Among the possible renewable energy sources, geothermal power generation stands out from the likes of wind and solar power as a constant source of energy production, not influenced by weather condition and able to supply power for 24 hours (Kubota, et al, 2013). Japan has a long history of geothermal energy exploitation, visible through the traditional *onsen* culture (soaking in thermal bath) as well as cooking method using geothermal steam, dating back to when Buddhism spread to Japan in the 500s (Geothermal Research Society of Japan, 2004). At the same time, situated on the Pacific Ocean’s Ring of Fire, Japan has a large potential in geothermal power generation, ranking 3rd in terms of the total amount of geothermal source. However, when it comes to power generation from geothermal energy, the situation in Japan has been lackluster and seen little noticeable change since the 1990 (Kubota, et al, 2013). In terms of capacity of power generation facilities, in recent years, along with the remarkable growth of geothermal development in Indonesia, New Zealand, Iceland and Kenya, in 2015 Japan is surpassed by Kenya (Figure 2), falling to the world's tenth place. In other words, despite the large potential, Japan has failed to grow. As seen from figure 2 illustrating the installed capacity of 4 countries with the sizable potential in geothermal resource America (39000 MW), Indonesia (27000MW), Japan (23000MW) and the Philippines (6000MW). It is clear that although Japan has a large amount of geothermal resource, in the period from 2010 to 2018, there is hardly any development for geothermal utilization at all, compared to the other 3 countries.

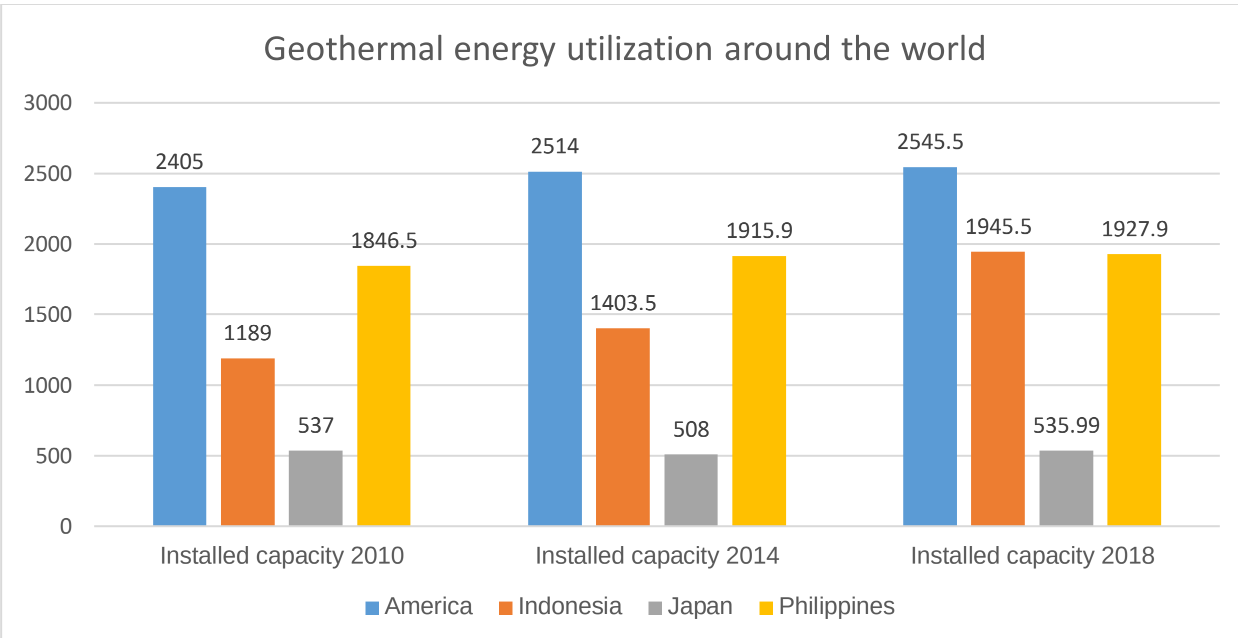


Figure 2 Changes in installed capacity of geothermal power generation from 2010 to 2018

Source: (IRENA, 2019)

The increasing focus on renewable energy together with the underutilization of geothermal energy potential has also spurred the growth of the number of initiatives towards the development of geothermal power generation. It is most visible in Oita prefecture where both renewable energy ratio and geothermal energy ratio rank first in Japan (Figure 3).

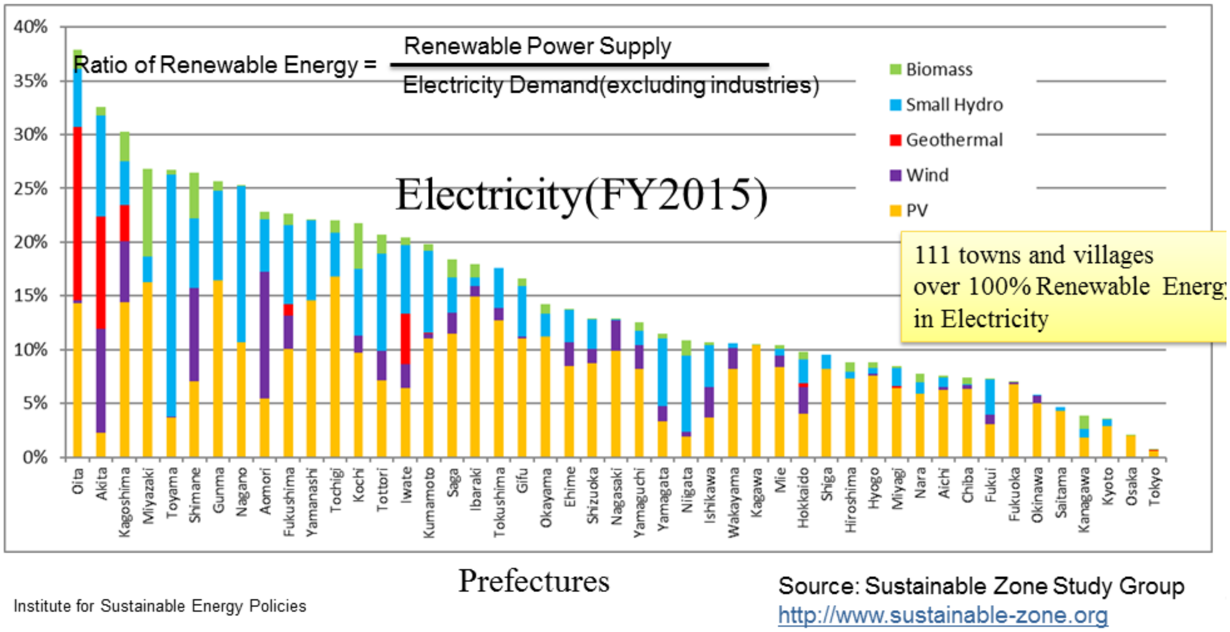


Figure 3 Energy Sustainable Zone: Indicator for Sustainability of region in Japan

Source: Ministry of Economy, Trade and Industry (METI), 2016

Beppu city, located in Oita Prefecture, apart from being a popular hot spring tourist spot with 2,558,698 tourists, including the local and repeaters, visiting hot spring facilities in 2016 (Oita Prefecture, 2017), is also where the first geothermal well in Japan was drilled in 1919 (Geothermal Research Society of Japan, 2004). Having the most number of hot spring well heads and hot spring yields in Oita Prefecture and Japan (Figure 4), in their effort to increase geothermal power generation, Beppu has looked to *onsen hatsuden* - hot spring power generation - as their main strategy. This method of power generation, in the context of the world and Japan's energy market as explained above, is the main focus of this study.

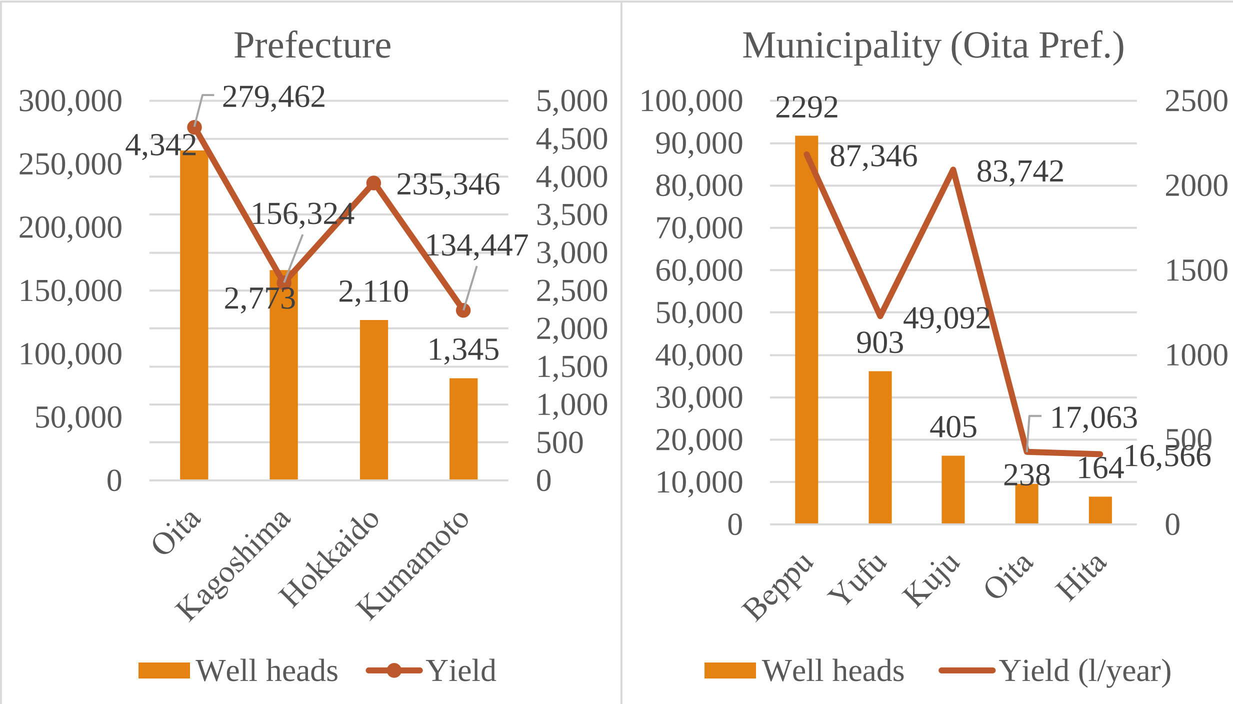


Figure 4 Oita Prefecture has the most number of hot spring well heads and yield in Japan, while Beppu has the most in Oita Prefecture.

Source: Japan Hot spring Society, 2014

II. Literature review

1. An overview of hot spring and hot spring power generation - *Onsen hatsuden*

This section serves as an introduction to the important concepts related to *onsen hatsuden*, starting from *onsen*, to *onsen hatsuden* and finally its mechanism.

a. *Onsen* – hot spring

Before starting this topic, it is important to understand what *onsen* is, not only because the word exist in *onsen hatsuden*, but also because this method of generation directly impact this resource which is highly valued within Japanese society. Conventionally, *onsen* - hot spring - has been mainly used for health and wellness tourism for centuries, with Japan oldest hot spring *Dogo onsen* in Shikoku dating back over 1500 years ago (Rátz, 2009). Terms such as *touji*, which "means the amelioration of symptoms through hot water", and *onsen* therapy, "an approach to health management through the use of hot spring water", are among the most popular cultural health practices, which are also the center of *onsen* tourism industry (Serbulea and Payyappallimana, 2012).

Within Japanese tourism industry, *onsen ryokou* (hot spring vacations) takes up a considerable proportion. According to the "Accommodation travel statistics (2017 · annual value (fixed value))" released by Japan Tourism Agency, Ministry of Land, Infrastructure, Transport and Tourism (2018), among over 509 million overnight guests, 37.5% stayed at a *ryokan*, a tourist accommodation type whose main highlights often include an *ofuro* (a common bathroom) using hot spring water. Oita prefecture, where Beppu city is located, markets itself as "Nihon ichi no Onsen-ken Oita", which translates to "Oita Prefecture – Japan's number one hot spring prefecture".

b. Definition

Onsen hatsuden, hot spring power generation is a method for utilizing geothermal resources, specifically 70~150oC hot spring resources prescribed in Article 2, Paragraph 1 of the Hot Spring Act (Law No. 125 of 1947) for the purpose of power generation. A hot spring power generation project involves installation of hot spring power generation facilities (such as the following output power generation facilities and cooling towers) as well as construction of the power plant.

Those who intend to invest in a hot spring power generation project, project investors, have to fulfil the following responsibilities:

(1) Communicating and reporting to Beppu city officials, neighboring officials and neighboring hot spring officials

(2) Consideration for related laws and regulations, as well as conservation of natural and living environment.

(3) Consideration for utilizing *regional resources* that are hot spring resources

(4) Appropriate management of facilities from introduction to disposal

(5) Immediate response at the occurrence of accidents and prevention of reoccurrence

Here neighboring officials refer to representatives of people living in area of neighborhood within 200m vicinity of the power plant, while neighboring hot spring officials refer to representatives of people who have the rights to utilizing hot spring sources within the 150m~300m vicinity of the power plant's heat source. Because of the intense water usage of geothermal power generation, water users within the vicinity of the power plant must also be considered as well.

c. Mechanism of hot spring power generation – Binary cycle generation

Onsen hatsuden uses binary cycle generation method as the primary power generation mechanism. In a closed or binary system, thermal energy is transferred to a secondary fluid, whose vapor is used to turn turbines and generate electricity. The secondary fluid or working fluid depends on the manufacturer and type of the binary geothermal plant, which includes isobutane and n-butane. This fluid is in a closed-looped system with no interactions outside the geothermal system, thus does not have any direct environmental impacts under normal operating condition. In case of earthquake or other unforeseeable mishaps, binary geothermal plants are considered to be the most reliable and hardy energy system on the grid, they are also able to quickly resume operation compared to other large power systems on the grid (Gad, 2015). Nevertheless, the plant would need regular maintenance to ensure optimal working condition. For the case of Yuyama Geothermal Power plant in Beppu, maintenance must be carried out 1 out of 3 working days to ensure that all components are working correctly. If the geothermal fluid's temperature is medium to low (about 150°C or less), it is not possible to generate power the conventional way by turning the turbine directly with the steam separated from geothermal fluids. In this case, geothermal fluids is extracted and used in heat exchangers, heating and evaporating an organic secondary fluid having a boiling point lower than that of water (such as CFCs, a mixture of water and ammonia, etc.), turning the turbine with the vapour of the secondary fluid (Figure 9). Since there are two working fluids (geothermal fluids and secondary fluid), this method is thus called binary generation.

Binary is by far the most used geothermal system, taking up 45% of existing geothermal units in the world in 2010 (Bertani, 2012 cited in Santos, et al, 2018). Considered to greatly expand the possibility of geothermal power generation in Japan, small and medium-sized power plants employing this power generation method are increasing year by year.

2. Process of investing in a new hot spring power generation plant

The Guidelines for "Ordinance for Regional Coexistence of Beppu City Hot spring Power Generation" updated on April 1st, 2017 (Beppu Environment Section, 2017) outline the process of investing in a new *onsen hatsuden* project.

a. Preliminary advisory process

As the first step of the application process, investors must go through a preliminary advisory process with Beppu city. To attend, investors are required to provide various forms of application, including application form, agreement contracts, hot spring power generation investment plan, company profiles and certificates. In these advisory sessions, investors report location and technical details of the planned facility, while being informed of land use, use of hot spring and geothermal heat resources, conservation of natural and living environment and resolution methods should conflicts arise regarding those issues, et cetera. After advisory sessions, investors should be equipped with essential information regarding setting up a power plant and identified all stakeholders involved. Beppu city will summarize opinions on jurisdictional procedures and notifies matters necessary for the completion of the preliminary advisory in the "Preliminary advisory matters report".

b. Certifications and permits

Upon receiving this notice, investors can move to the steps - applying for a variety of necessary certifications and permits. In accordance with the contents notified from Beppu city, investors must apply for permits within relevant laws and ordinances of the main office to the relevant departments. There are around 87 relevant laws and ordinances that investors have to adhere to and depending on the location and characteristics of the plant, the number of permits and certificates might increase or decrease. Upon receiving all of these permits, Beppu city will organize the contents of the procedure into “Statement of completion of related laws and ordinances proceedings”, which is necessary for the application process.

c. Communicating and reporting to neighboring officials and neighboring hot spring officials

Apart from Beppu city, investors also have a duty to communicate with and report to neighboring officials and neighboring hot spring officials about the new hot spring power generation plant. As defined above, neighborhood within 200m vicinity of the power plant is considered. Investors have the responsibility to report to local people by holding various information seminars and local briefings. Participants include neighborhood cooperatives, neighboring hot spring cooperatives and neighboring water users. Investors are required to acquire signatures of participants as a form of consensus recognition certificate. In development of hot spring power generation, this process of getting the approval and reaching a consensus with local people is extremely important and challenging at the same time.

d. Environmental Impact Assessment

Investors are required to carry out an environmental impact assessment (EIA) of the power plant’s potential impacts on the local natural and living environment. The EIA are conducted with accordance to prefecture and city regulations before the construction of any geothermal plants in Beppu city. for geothermal power plants with capacity over 10000 kW (classified as Type 1 business) and 7500 kW (classified as Type 2 Business), EIA reports must be conducted and submitted to the Prefecture Environmental Conservation Division (県

環境保全課大気保全班) for their approval. Because the approval of EIA is under the jurisdiction of the prefectural government, Beppu city does not store records of this document and only requires that investors have the proof of approval from the prefectural government. Also, the local government stated that since the must submit an EIA that adheres to the EIA law (環境影響評価法-大分県環境影響評価条例) which was carefully drafted by Oita Prefecture, the local people can rest assured that whichever company successfully get approved under this law is legitimate. This eliminate the necessity to publish the complete document of EIA, and only summarized and presented to relevant parties if necessary. Because most *onsen hatsuden* plants has much smaller capacity, they often conduct EIA to be presented as part of the business plant or as required by the various divisions and law they need to comply. As of August 2018, there are 27 constructed hot spring binary geothermal plants (Beppu city government, 2019).

There are 4 main categories of impacts to be assessed: issues such as air pollution, noise, vibration, odor et cetera; influence on rivers, waterway et cetera.; influence on underground resources such as fumarolic, hot spring water and groundwater; influence on natural environment and living environment when natural disaster occurs. In addition, investors must also submit a noise prevention plan as well.

e. Acquiring certificate of completion of preliminary advisory

Having completed all necessary procedures and acquired all permits, investors will be granted the Preliminary advisory completion report to be submitted for inspection in the city hall. After the document screening is finished and Beppu city approves of the project, granting the Beppu city's "consent form", "Certificate of completion of preliminary advisory" is granted, followed by a monitoring process before construction start. This process, which can take place from 6 months to more than a year, monitor the potential amount of energy produced and usage of hot spring resources to adjust the output of the power plant. Construction of the power plant must ensure compliance with technical and safety requirements. Upon completion, investors must report to Beppu city hall within 10 days for a final on-site inspection.

According to an official in Kyushu Electrics company and a geothermal researcher in Fukushima that the author had to chance to interview in the *onsen* Summit 2017 in Oita, Japan, it would take 10 to 15 years from planning to completion of a new power plant with large scale (>7500kW) such as flash geothermal power plants, where extensive surveying and drilling is required. For small scale hot spring binary geothermal plants (<500kW) the process is shorter 3-5years as the utilize current hot spring wells and dependent on the speed which the plant is constructed and application. Due to this shorter time requirement, the pressure from central government for more renewable energy and lacking proper guidelines and policies in the years following the Fukushima incidents, there were cases in Beppu where geothermal power plants were built in an extremely short amount of time.

> *"Back then the law was relaxed and permits were given rather liberally, anyone who had the financial capabilities and completed the procedures for establishing a new business could pretty much set up a new* onsen *hatsuden power plant"*

Beppu city officer, Environmental Sector

After the policies reforms happened in 2014, there were significantly less cases of such power plants being built as quick "cash grab" for businesses.

The figure below summarized the entire process of application and planning

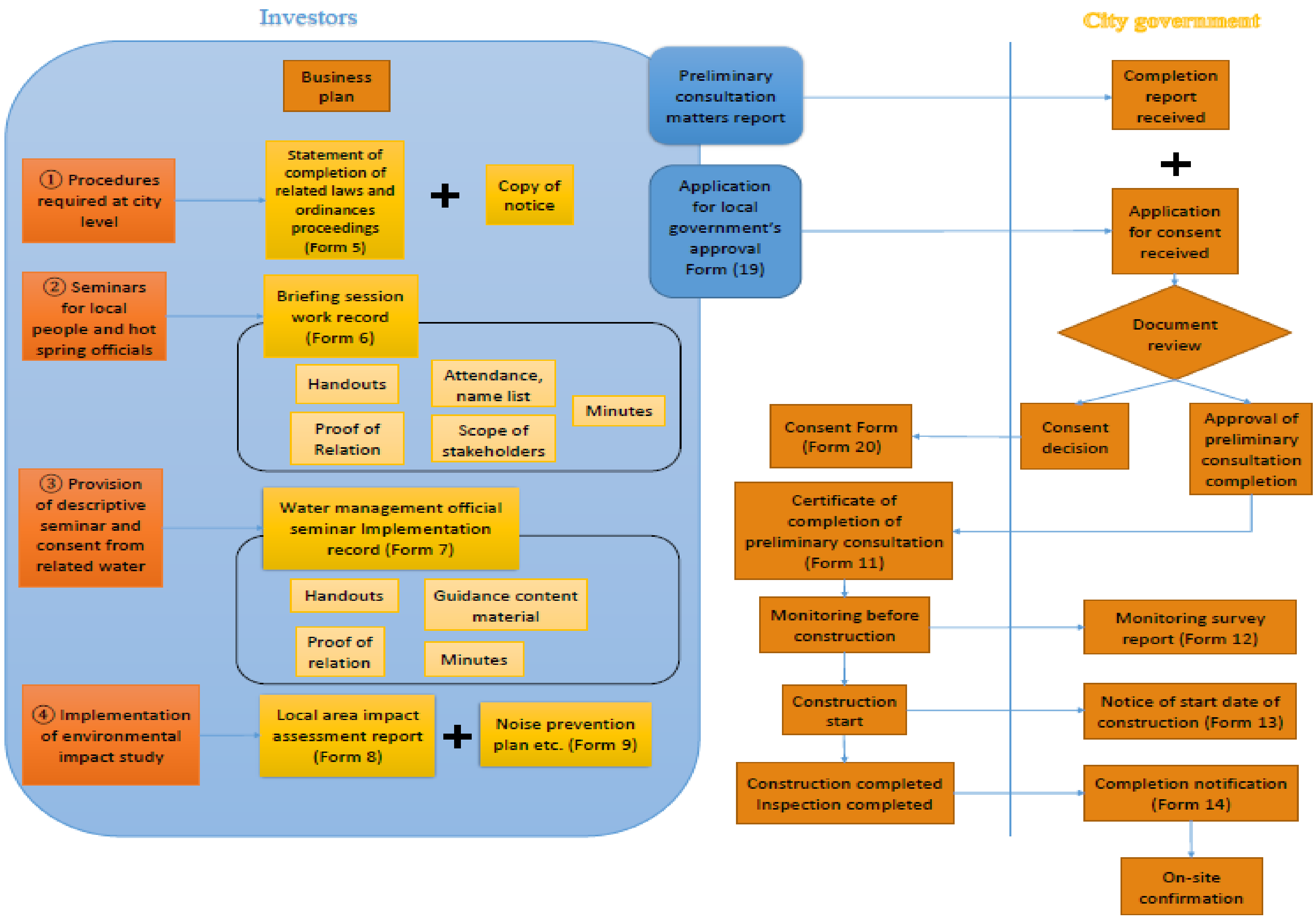


Figure 5 Application and decision making process

Source: Author

3. The conventional hot spring usage and the case in Beppu

a. Conventional *onsen* utilization

An important advantage of *onsen hatsuden* as a geothermal power generation method is allowing cascade utilization of hot spring resources. To clarify this, it is important to understand how traditionally, hot spring in Japan is extracted from hot spring wells, used for bathing (*onsen*) and cooking (*jigoku mushi*), then discharged into rivers (Figure 5).

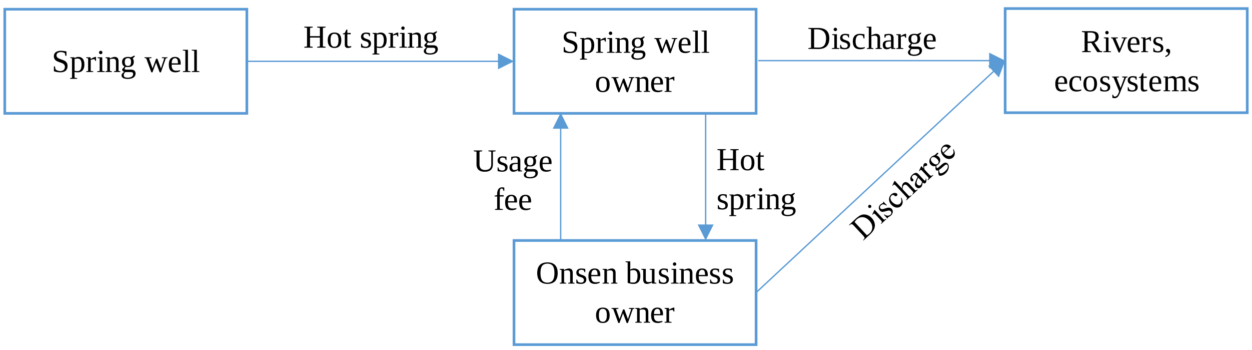


Figure 6 The conventional onsen business model's utilization of hot spring

Source: Author

In the conventional *onsen* business model, hot spring well owners pump hot water from the underground geothermal reservoir to be used in *onsen* business owners' facilities, mainly hotels and communal bathhouses, in return for a usage fee (Cosmotec, 2017). In many cases, the spring owners themselves own an *onsen* business. As a common practice, hot spring supplied to these facilities is pumped continuosly at a constant rate, creating a large amount of inevitable excess hot water discharged directly into rivers (Yamada, et al, 2018). The hot water pumped from geothermal reservoir, which can reach up to 150°C, cannot be used immediately and has to be cooled down to around 40°C through outdoor cooling stations (Figure 7), putting the potential thermal energy to waste. This practice in conventional *onsen* business model is not only a waste of natural resource, but also adversely affecting the environment. For instance, in the Miyamae *onsen* of Kannawa district, a binary hot spring geothermal facility is built in the place of the cooling towers to utilize the heat electricity generation while cooling the water to a lower temperature for the hot springs.

Figure 7 Cooling towers for hot spring water in Beppu

Source: Author

b. Impacts of conventional *onsen* utilization – the case of Beppu

In Beppu, drilling of geothermal wells have started mainly in lowland areas since as early as 1880s (Ohsawa, 2018). By 1920s, the number of wells increased to about 1000 and after the second boom of exploration in 1960s, there were around 2500 wells in use by 1970s (Ohsawa, 2018). Due to the flurries of exploitation, the level of groundwater table has significantly decreased and since 1985, little drilling has been done. Over the years, some wells have been out of use and in 2014, there are a total of 2217 wells in use (Japan Hot Spring Society, 2014). The volume of water extracted is 83,058l per minute, highest in Japan (Japan Hot Spring Society, 2014).

Several researches on the potential impacts of the traditional hot spring usage as described above have been done, outlining results and data on rivers and ecosystem of areas surrounding hot spring power plants in Beppu (Nishimura, et al, 2018, Yamada, et al, 2018, Ohsawa, 2018). Micro-binary hybrid measurement results indicated that changes in gravity level measured happened due to ground water level changes, speculated to have been caused by exploitation of hot spring (Nishimura, et al, 2018). There also exists a tradeoff between hot spring use and river ecosystem (Yamada, et al, 2018). In Beppu, water with temperatures above 45°C are not allowed to be discharged into city sewers under the Beppu city ordinance, which means thermal water will be discharged into rivers. For areas like Kannawa and Myouban, hot spring drainage system is severely lacking and outdated, which resulted in both used and unused hot spring being uncontrollably discharged directly into rivers. This creates temperature changes (specifically sharp increases) along the river where many bath houses situate, which ultimately facilitates a suitable environment for invasive species to flourish in estuaries. Furthermore, constant drainage of unused hot spring water likely increases the metallic elements discharged into the Beppu Bay Area. Metallic elements include arsenic 4.3tons, boron 82t, lithium 34t, cesium 0.4t, rubidium 5.4t are discharged into rivers and ocean annually. In other words, *onsen* resource utilization in Beppu has clear and measurable negative impact on the local ecosystem and environment.

Although little drilling has been done since 1985, there has been signs of over exploitation of hot spring (Ohsawa, 2018). Wells like the one in Tenman-cho, an area only 1.2km away from the beach where elevation is relatively low, has stopped flowing since February 2006. This is an alarming sign indicating that onsen water level has gotten so low that even places with low elevation level now no longer has onsen. Since natural pressure has significantly decreased, addition mechanism which involves the use of pumps in an 'air-lift' method is now used to extract thermal water to the surface for hot spring utilization. Before 1968, at least half of the wells had been flowing (as in discharging steam, boiling water, and artesian water), but now, two third of wells in used no longer naturally flows and has to employ pumping mechanism (Yusa, et al, 2000). Development of hot spring utilization is also unbalanced because of the outdated restrictions. Although new well drilling has to follow a strict set of restriction, which only allows extraction rate of 50l per minute, older wells drilled before 1968, classified as natural wells, are still allowed to extract 1000l per minute. To add to the problems, most of these wells were not drilled without sufficient scientific research, meaning some could tap into heavy metal layers (such as arsenic), bringing these toxic materials with hot water and pollute the entire system.

These problems call for a more efficient utilization of hot spring resource, and *onsen hatsuden* could be part of the solution, as there is no need to drill new wells and making use of otherwise wasted heat energy for electricity generation.

4. *Onsen hatsuden* and cascade utilization of hot spring resources

Onsen hatsuden plants using binary generation method have several advantages compared to the other geothermal power plant types, dry steam plants and flash plants. Because geothermal fluid does not directly enter the system nor comes into contact with working parts, risks of erosion can be minimized. It is also possible to utilize geothermal resource with low temperature (below 150°C). Capacity of binary systems can be as small as several hundreds of kW to tens of thousands of kW (Yamada and Oyama, 2004).

Most importantly, the mechanism of binary power plants allows for simultaneous production of electricity and hot spring for bathing. High temperature hot water enters the system of *onsen hatsuden* power plant and generates electricity, is then cooled down in the process to a temperature suitable for bathing and used in *onsen* facilities. Adding binary power generation would also allow for management of hot spring discharge, reducing the amount of direct discharge into rivers. The following diagram describes how *onsen hatsuden* can improve the *onsen* business model, showing a cascade usage of hot spring resources, as opposed to the traditional system.

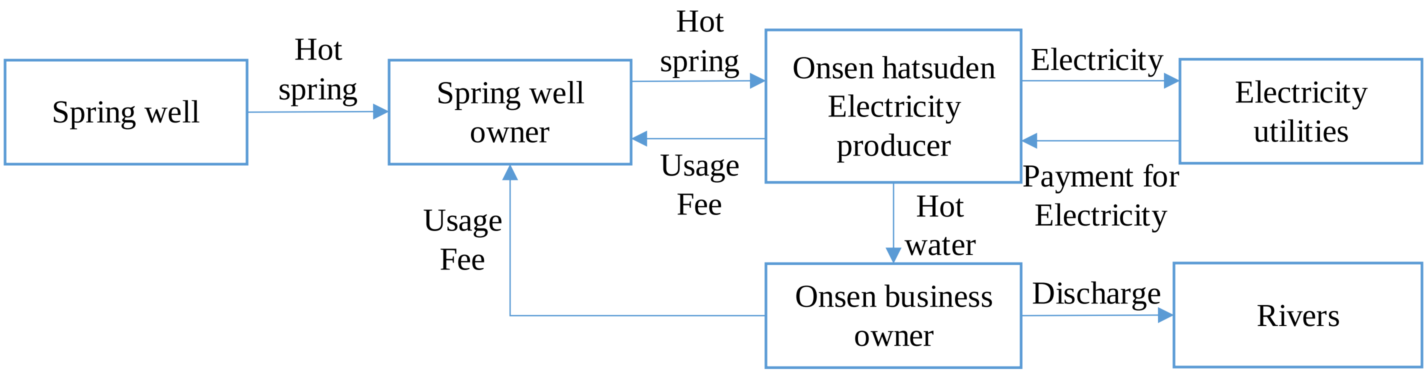


Figure 8 Cascade usage of hot spring with onsen hatsuden

Source: Author

Despite the advantages *onsen hatsuden* may provide, it is still a geothermal power generation method at its core, whose development faces obstacles created from a lot of negative perspectives, which are explored in the next section.

5. Stakeholders in *onsen hatsuden* planning

As seen from the process of application for new *onsen hatsuden* project above, the most notable stakeholders are the government (local and central), partners (financial collaborators and research institutes), the local citizens and *onsen* business owners. During the application process, investors are required to go through various meetings and procedures in order to obtain necessary permits. Most importantly, they have to gain the consent of local citizens and *onsen* business owners. Because *onsen* is revered as an important *regional resource* that everyone must take responsibility in utilizing, reaching a consensus over usage hot spring with local people is one of the top priorities. Furthermore, although the final decision lies in the hands of local government, especially in the case of Beppu, local government highly prioritizes opinions of local residents and *onsen* business owners, making them the most important stakeholders for *onsen hatsuden* investors.

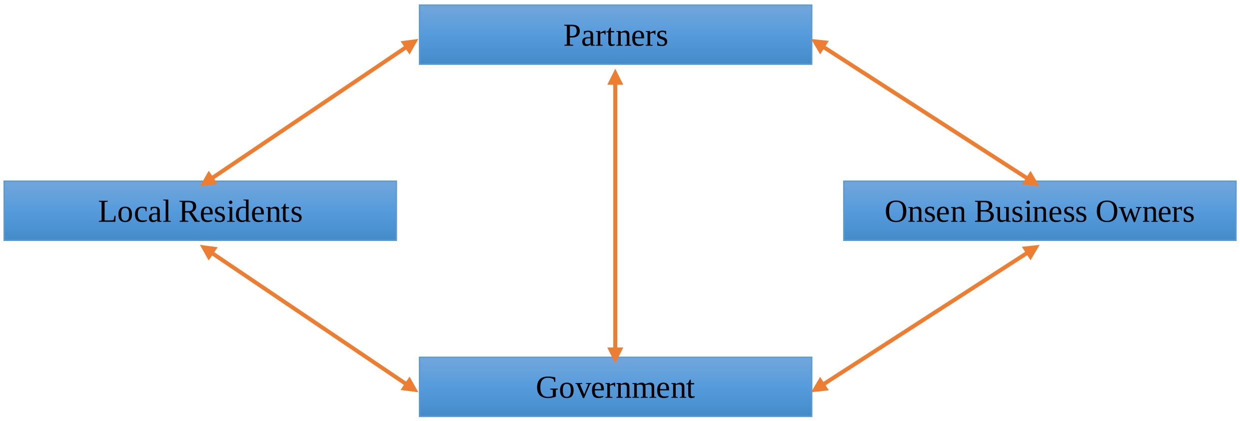
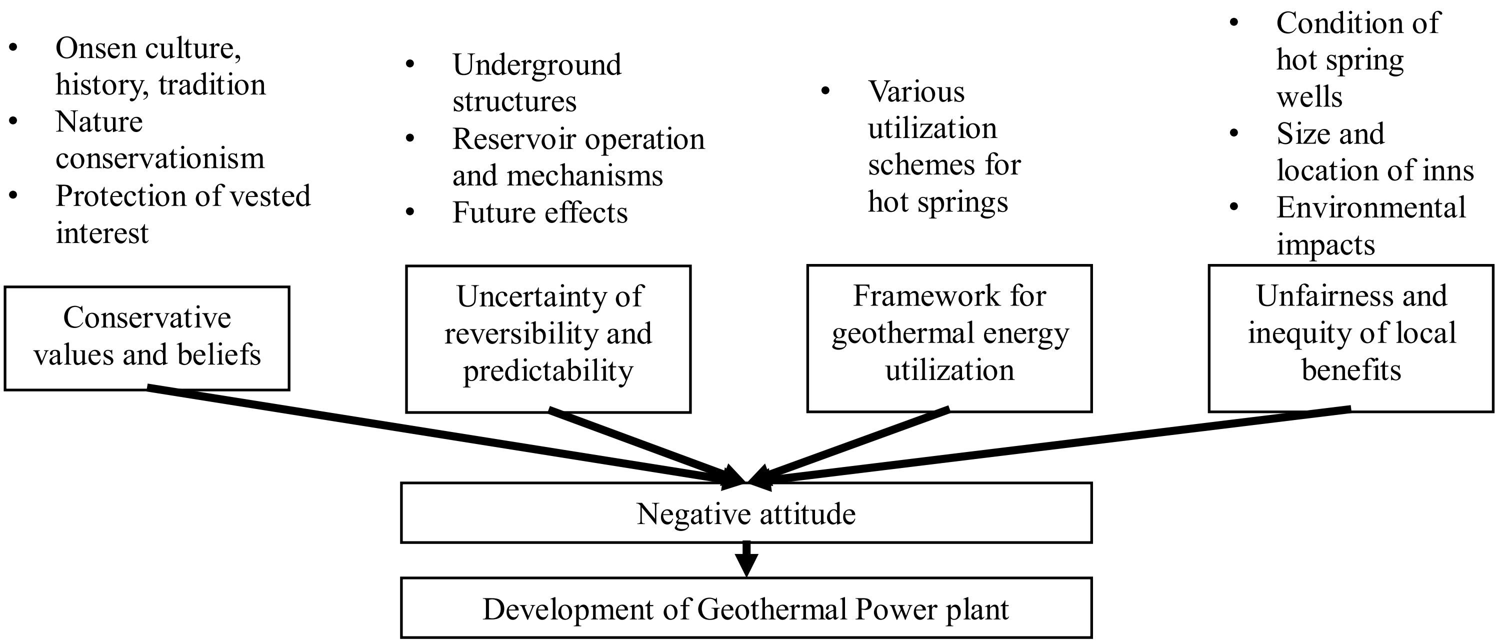


Figure 9 Local stakeholders for onsen hatsuden project

Source: Author

6. Perception of geothermal power generation in Japan

In the case of Japan, there is often a negative perception of geothermal power plants, among other reasons, interfering with planning process. The strongest criticisms of geothermal power often come from hot spring owners and cooperatives (*onsen kyoukai*) (Kubota, et al, 2013). They are generally strongly protective of onsen, Japanese hot spring culture, arguing that geothermal power generation would adversely affect the spring source and quality, ultimately jeopardizing the survival of related hot spring businesses. There is also concern over the uncertainty of geothermal power projects, which are highly susceptible to damages from earthquakes and tectonic activities, something Japan is particularly famous for. When comparing the energy generated from geothermal sources to the total energy demand in Japan, the percentage remains relatively low, contributing to hot spring owners' reluctance in considering geothermal power plants' necessity. The benefits from a geothermal plant to a local community are also controversial as there is always a conflict of interests with hot spring wells and inn owners. The following figure summarized the background of negative attitude of hot spring inn managers towards geothermal power



(Kubota, et al, 2013).

Figure 10 Negative perspective on geothermal power

Source: Kubota, et al, 2013

This leave the question whether the same perspectives of stakeholders would still have the same impact on development of hot spring power generation.

To further look into this issue, this paper addresses the case of hot spring power generation planning in Yuuyama hot spring generation power plants, Beppu city.

III. Research question

Based on the literature review above, there are several important points to take notes of:

- From the process of investing in a new hot spring power generation power plant, we can see that *onsen hatsuden* is mostly handled by the local government since they have the legal authority to permit construction of plants (Kubota, et al, 2013). However, in decision making, without the consent of stakeholders such as local residents, hot spring owners and businesses, it is highly improbable to get the plan approved. It is thus important to consider stakeholders' perspectives on hot spring power generation as their opinion is held in high regards by the local government (Kubota, et al, 2013).
- Conventional *onsen* business model is not only a waste of natural resource, but also adversely affecting the environment. Researches have shown that the current utilization of hot spring sources has adversely impact the local environment and call for a more efficient usage of this resource. This is where cascade utilization of hot spring resource and *onsen hatsuden* can come into play.
- At the same time, it is important to keep in mind that when it comes to *onsen hatsuden*, there are many stakeholders involved in its development, who can be categorized largely into the government, business partner, *onsen* business owners and local residents.
- There is a generally negative perception from stakeholders, particularly from the *onsen* business owners' point of view when it comes to the development of *onsen*

hatsuden, which can greatly hinder the process of further developing this sector of renewable energy.

From these points, we can infer that for policy makers who would like to further develop this renewable energy source, it is important to understand who the main stakeholders are and their perspectives on the subject matter, as their opinion can greatly impact the overall process of development. Therefore, it would be interesting to investigate what some of these stakeholder perspectives could be as it would provide valuable points of reference for further policy making. For this reason, based on a case study of a *onsen hatsuden* project conducted in Beppu, this paper will answer the following question:

1. *What are the stakeholder perspectives on hot spring power generation?*
2. *Do the same stakeholder perspectives of geothermal power generation still apply to hot spring power generation?*

IV. Case study site: Yuuyama hot spring power plant, Beppu

As part of Beppu's New energy Initiative, the Yuyama hot spring plant was established in 2014 by North Japan Geothermal (NJG) company and has been running ever since. The hot spring power plant has a 15-year contract with Kyushu electric to provide electricity to be sold at 43.2 yen / kWh. The power plant has 2 generators with net power output of 120 kW and runs 24 hours a day, with 1 day of alternate down time for each generator after 2 days of work. Although the maximum capacity is 60 kW for both generators, in reality, the output only amounts to 40kW each or 80 kW for both. In other words, in a year Yuuyama power plant is expected to produce about 467200 kWh per year, or a revenue of around 20 million yen per year if there is no unscheduled down time due to natural disaster or unexpected break down.

$$E_{(kWh)} = P_{(kW)} * t = 80 * 365 * \frac{2}{3} * 24 = 467200\ (kWh)$$

Table 1 Outline of facilities of the Yuuyama Geothermal Power Plant (West Japan Geothermal Company, 2018)

<table>
<tr><td colspan="2">Site area</td><td colspan="2">Approx. 230 m^2 with diamensions 23.0m X 20.0m</td></tr>
<tr><td colspan="2">Power output</td><td colspan="2">Maximum net power output 100kW</td></tr>
<tr><td>Power generator</td><td>MB-1</td><td>2 mirco binary generators
Max. Gross output: 144kW (72kW x 2units)
Max. net power output: 120kW (60kW x 2units)</td><td>Unit casing
Semi-closed screw-turbine generators, organic Rankine cycle
Working medium: Organic medium HFC245fa with the boiling point of 15.3^{o}C and the melting point of -107^{o}C</td></tr>
<tr><td>Cooling tower</td><td>CT-1</td><td>Open cooling tower with 3 cells
Cooling capacity: 2.038 kW
Circulating water flow rate: 4,000 L/min</td><td>Measures against dead leaves: Watering tank cover and leave prevention nets
Water quality control: chemical dosing equipment (with 2 layer agents) and electric conductivity control</td></tr>
</table>

Tank	T-1	One buried hot-spring drain tank made of FRP Effective capacity: 1,500 L	Hot spring steam drain tank
Pump	CDP-1	2 cooling water pumps 4,000 L/min x 15.0kW (inv)	Manual inverter control One for regular service and other for backup
	HP-1	2 cooling water pumps 2,500 L/min x 11.0kW (inv)	Manual inverter control One for regular service and other for backup
Heat exchanger	HEX-1	3 plate heat exchangers Heat exchange capacity: 1.082kW	Heat exchangers for hot spring water and hot water 2 for regular service and the other for backup
Electric equipment		One outdoor cubicle Dimensions: 4,700 W x 2,320 D x 2,430 H Power receiving facility capacity: 180 kVA High-voltage incoming panel, house power, power board, low-voltage power board and islanding prevention device	Outdoor CB type with enclosed switch board
		Remote system Remote image monitoring, measurement monitoring and issue of alarms by email	Monitored at point 32 points remotely from the head office of the Western Japan Geothermal Power Generation. System of issuing alarms by e-mail to nine relevant departments
Geothermal heat	Steam well	Onsen Jigoku One well of 80A (approx. 110 m deep) with a steam flow of approx. 8,450 kg/h	Source: Located on the premises of Tsunematsu family residence

The Yuuyama power plant rents an existing hot spring source and was established in a private property. Construction started on May 7, 2014 while the plant was certified as a renewable energy generation facility on July 11. Power generation began on October 30th, 2014. The power station lies within the far-reaching plateau of Yuuyama village where 25 families (households) mainly consisting of seniors live. The east of the facility is blessed the scenic beauty of Beppu Bay.

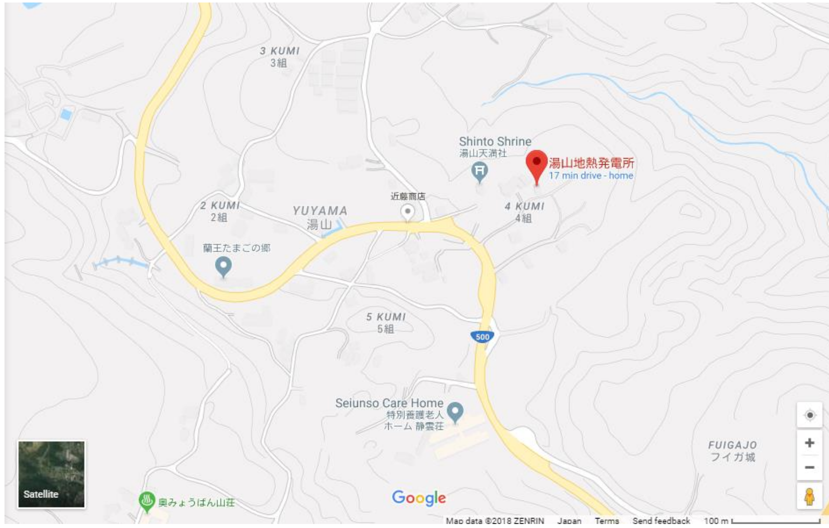


Figure 11 Yuuyama hot spring power generation plant (Taken in July 2018)

Location: Oita Beppu City Yuuyama 4 kumi Oita Expressway; 15 minutes by car From Beppu IC Route 500 towards Juumonjibaru SA.

V. Significance of the study

Answering the research question would shed light on what the stakeholders' perspectives are regarding *onsen hatsuden* and also address whether the same perspectives of stakeholders for geothermal power generation would still hold true for development of hot spring power generation. Based on the result, policy makers can understand the differences (or similarities) in what is the important factor to consider when designing future power generation plans.

VI. Methodology

1. Q methodology

This study employed a multistage method of research called Q methodology. Q method is defined as the development of a set of statements expressing potential stakeholders' attitudes and beliefs about a particular issue, ensuring coverage and balance of the topic (Watts and Stenner, 2012, cited in Diaz et al, 2017). It uses factor analysis of rankings of qualitative statements to identify and understand the range of social perspectives that exist on the topic (Winkler and Nicholas, 2016). The factors resulting from Q analysis thus represent clusters of subjectivity that are operant, i.e., that represent functional rather than merely logical distinctions (Brown 1993).

Q method involves the following process:

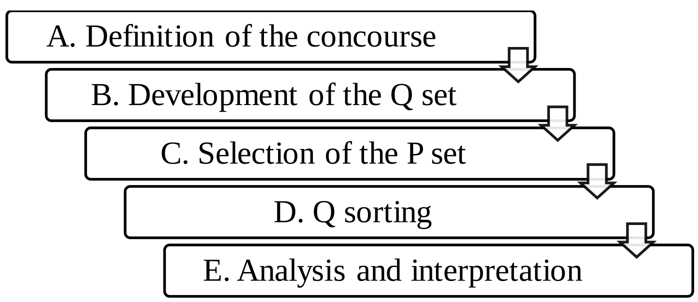


Figure 12 Q methodology

a. Definition of the concourse

A concourse refers to a technical concept used for the collection of all the possible statements the respondents can make about the subject at hand, to "the flow of communicability surrounding any topic" in "the ordinary conversation, commentary, and discourse of everyday life" (Brown, 1993). For this study, the concourse was identified through literature review of stakeholder perspective on geothermal power development and interviews with affiliates of geothermal power generation conducted with a power plant owner and during *Onsen* World Summit 2018.

b. Development of the Q set

From the concourse, a set of statements is drawn from the concourse, to be presented to the participants selected on the basis of their involvement with the power plants (the P set), making up a Q set of 41 statements. Statements (Table 2) fall into 3 categories: statements made about planning process, statements on energy policies related to *onsen hatsuden*, and statements about the respective power plants. They are related to 5 spectrums of perspectives on renewable energy development: regulation, society, economy, environment and technology (Diaz, et al. 2017). The author subjectively selected statements to represent a wide variety of perspective participants can have on the subject matter. Participants are asked to rate statements following the rule: 'To what extend to you agree with the following statements on the scale from -3 (Least likely to agree with) to 3 (Most likely to agree with)'. The participants were informed that they should make their judgement based on their own experience with the Yuuyama geothermal power plant and its influence on the local community. Q sort is then conducted and followed by factor analysis and correlation analysis to find out dominant factors representing different perspectives.

Table 2 Q set

Planning	Reg	1	The plant presents a grave risk to the *onsen* source
	Soc	2	I could not influence the results of the decision process.
		3	All stakeholders should be involved in decision-making.
	Econ	4	Onsen has a long tradition, heavy cultural implication and thus is highly prioritized
		5	The plant is a "win win" situation for everyone.
		6	In the decision process personal interests are given preference over project interests.
		7	Tourism aspect of the plant must also be considered

	Env	8	In the decision process my main motivation was to produce renewable energy.
	Tech	9	I understand the mechanism and technology behind hot spring generation
Energy policy	Reg	10	I make my decision based on my knowledge of hot spring generation
		11	The whole political apparatus could work faster.
		12	In Beppu, it is easy to hold a roundtable with everyone to make decisions.
		13	energy regulators should address the issue of energy efficiency before focusing on development of hot spring power generation
	Soc	14	The decision process was not complicated
		15	In projects planned at national level, local interests are enough considered.
		16	local government holds more power in decision making than central government regarding hot spring power plants
	Econ	17	Local citizens hold the most power in decision making
		18	local residents should not have autonomy in deciding their energy sources
		19	Comparing the project's electricity with the market price, the energy policy seems senseless.
		20	We have to produce as much energy as possible to meet our needs.
		21	there is no need for more hot spring generation (because we already have high percentage of geothermal power)
		22	The initial investment cost is too high
		23	The profit return is uncertain
		24	Concerns for environmental problems is low in Beppu
	Env	25	The energy strategy should focus on how to protect our nature.
	Tech	26	In Japan we do not have to produce more renewable energy.
		27	The green lobby has a strong influence on the government.
		28	We should enhance the energy efficiency (efficient appliances, roof isolation).
		29	In Japan, we should improve the efficiency of hot spring usage
Power plant	Reg	30	In Japan, we should not limit the conventional energy sources (non-renewable).
	Soc	31	The electricity for the municipality is secured with the Yuyama power plant
		32	I am satisfied with the current level of preparedness for unexpected problems happening in the plant
		33	The community has not gained significance with the power plant
	Econ	34	Local residents have the best knowledge about community energy needs.
		35	The plant should play a role in reviving the local region

		36	The plant is not a profitable business
		37	the power plant would have positive effect on local economy
	Env	38	the power plant is not a resource for tourism
	Tech	39	I am well aware of the possible environment impacts of the plant
		40	I have the feeling that the ecologic cons and the power production are well balanced.
		41	The technology implemented in the power plant is not sufficient

c. Selection of the P set

The snowball method of selection was employed to develop the P set. Participants were first selected based on their involvement with geothermal power development in Beppu city, then asked to provide a list of prospects to the study. A total of 11 participants were involved in the Q sort. All of these participants were directly involved with the Yuyama power plant decision process, where the government act as the mediator for discussion and interaction between all stakeholders including the power plant owner, the business partners, the local *onsen* business owners and local residents. These participants are chosen to act as representatives by their own respective groups for their involvement with the project.

Table 3 Participant list (P set)

Category	**Position**	**Affiliate**
Company	1. Manager	Geothermal Power plant
Government	2. Environmental Specialist	Ministry of Environment (MOE)
	3. Section Chief of conservation of hot spring	Beppu *Onsen* Section
	4. Beppu city officer	Beppu Environmental Section
Onsen business owners	5. Representative	Onsen Cooperatives
	6. Owner	Hot spring/ hotel
Partners	7. General Manager, Geothermal power department	Kyushu Electrics
	8. Deputy director	Renewable energy Research Center
Local residents	9. Land owner	None
	10. Local residents	None
	11. Local residents	Cooperative representatives

d. Q sorting

The participants were asked to sort these statements into a matrix according to their level of agreement to the statement as follows:

Table 4 Statement matrix

-3	-2	-1	0	1	2	3

After the sort, an interview was conducted to gain further insights on why each participant place a statement at the extreme end (-3 or 3), neutral (0) or any particular observation and opinion they had.

e. Analysis and interpretation

In Q methodology, data is analyzed through a factor analysis, which is a way to reduce a data set with a lot of data point through correlations and allow researchers to describe the data set and account for its variances.

The basics of Q analysis

Analysis of Q methodology is carried out through "by-person correlation and factor analytic procedure" (Watts and Stenner, 2005). It is the "overall configuration", the structure of responses given by the participants that is analyzed. Q sort factor analysis looks for similarity between participants through the way each participant configured their answers into a sort. Therefore, in Q method, rather than the similarity between each response within one sort to another's, correlation analysis tries to find how participants' response matrix configuration correlate with one another. In the end, we would like to identify the thought perspectives that clusters participants together causing them to have the similar configuration. The process is illustrated through figure 13.

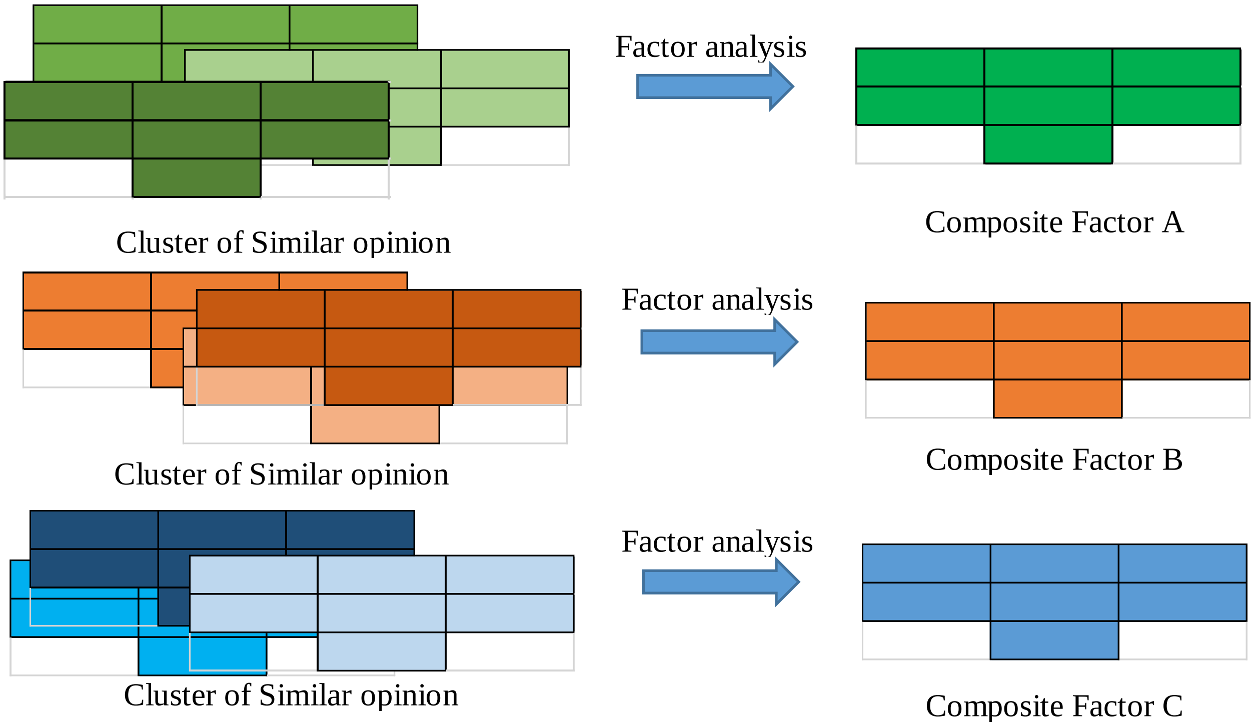


Figure 13 Factor analysis of Q methodology

A factor, i.e. a configuration on to which participants can load their own basis of configuration, can be extracted in the presence of 2 or more participants with a similar basis of configuration. Each of these factors is unique and represents a perspective on the subject matter, which is the desired results of this analysis. These factors can be represented using the same set of statements that were used in the research.

Q method's factor analysis with Ken-Q analysis tool

For this paper, the result of Q sort is analyzed via the methodology outlined in "A Primer on Q Methodology" (Brown, 1993) and with the help of Ken-Q Analysis, a web-based application for Q methodology. Figure 14 explains the steps for factor analysis after obtaining correlation matrix in Q methodology.

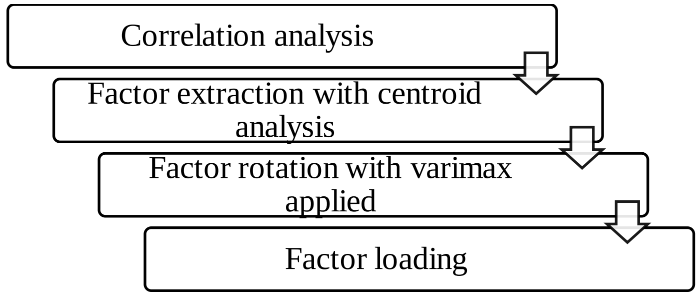


Figure 14 Q method Factor analysis

First, a correlation matrix between participants' answers in the dataset is constructed. The calculation method for correlation matrix is further detailed in the section below.

Based on the correlation matrix, factor extraction is carried out through centroid factor analysis, which is an agglomerative clustering method where each data point is a cluster, and "similarities (or dissimilarities) among clusters are defined in terms of the centroids (i.e., the multidimensional means) of the clusters on the variables being used in the clustering" (Lewis-Beck et al, 2004). Here, the factor analysis attempts to determines the number of factors – families of highly correlating Q sorts – there are in the dataset (Brown, 1993). Using centroid factor analysis, an initial set of factor loadings is extracted, where the loadings express the extent to which each Q sort is associated with factor (Brown 1993). This initial factor loadings serves as raw material for examining the perspectives of interest via rotation in the next step.

Among the factors extracted, only those with eigenvalues – characteristic values of the dataset - larger than 1.00 would be kept for factor rotation, as any factor with eigenvalue less than 1.00 would serve little to explain the overall study variance (Watts and Stenner, 2005). Factor rotation is carried out with varimax applied as it provides the most mathematically informative solutions (Watts and Stenner, 2005).

Finally, based on their loading factor, at least 2 participants' configurations are loaded onto the suitable factor, and the results of factor rotation and loading would represent the unique perspectives of stakeholder in this study.

2. Significance of Q methodology

Q methodology is especially helpful in single case studies on subjectivity due to its systematic approach and analysis. Various statements are naturally occurred discourse gathered from the participants themselves, which can be condensed to 3 or 4 operant factors with minimal intrusion from the researchers. Despite the fact that we cannot measure the proportion of general population who share the identified perspectives, or that other perspectives also exists outside the scope of the study, we can proceed with full confidence that what we have discovered through Q methodology in fact does exist (Brown, 1993).

On one hand we have qualitative research which heavily relies on statistics and number attempting to study a subject objectively, while on the other we have qualitative research which is often used more effectively to describe human experience. Q methodology is what could be called a lovechild of these two ends of the spectrum in research: it marries the depth and scientific principles of qualitative research with mathematics and simple to understand statistics, increasingly made simple with the help of computer software.

It is also important to note one drawback of the Q methodology. Although the concourse is defined through objective data collection on the subject matter, the Q set is defined subjectively by author using a structure for selecting a wide range of representative statements within research purpose, thus it can be "more an art than a science" (Brown, 1980).

Nevertheless, following this method, we would be able to identify which groups of statements likely represents a perspective, in other words, a factor influencing the decision-making process of hot spring power generation. Analyzing the degree to which they agree with the statements would also shed light on to what extend do each perspective impact decision making process of hot spring power generation.

VII. Findings and results

3. KenQ analysis findings

From here on, the Participants are referred to by their corresponding number as listed in **Table 3** Participant list above. Keeping that in mind, analysis of the q sort data yielded the following results.

a. Correlation analysis

First, correlation between participant configurations was calculated. For demonstrative purpose, let us calculate the correlation between participant 1 (P1) and participant 2 (P2) as an example. The table below shows the 2 participants' Q sorts' scores, the difference between their scores represented by row D and D^2 is the difference squared:

#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
P1	-2	1	-1	2	2	1	2	2	1	3	2	-3	0	-1	-2	-1	3	-1	-2	0
P2	2	1	-3	3	1	-2	2	1	2	2	-2	-3	-2	0	-2	-1	-2	-1	1	0
D	4	0	-2	1	-1	-3	0	-1	1	-1	-4	0	-2	1	0	0	-5	0	3	0
D2	16	0	4	1	1	9	0	1	1	1	16	0	4	1	0	0	25	0	9	0

#	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	Sum
P1	-3	1	-2	0	3	-3	0	1	3	-3	0	-2	0	-1	3	-2	0	-3	1	2	-1	0
P2	0	1	0	1	0	-2	-1	3	3	-1	-3	2	3	-3	-1	0	-1	0	3	-3	2	0
D	3	0	2	1	-3	1	-1	2	0	2	-3	4	3	-2	-4	2	-1	3	2	-5	3	0
D2	9	0	4	1	9	1	1	4	0	4	9	16	9	4	16	4	1	9	4	25	9	228

*P1: Participant 1, the values represent the statement score given by participant 1 in their Q sort.
*P2: Participant 2, the values represent the statement score given by participant 2 in their Q sort.
*D: Difference between score given by P1 and P2
*D2: D squared

To arrive at the correlation between participant 1 and 2, firstly, we must square all the scores given to each statement in the q sorts, then summing them all up, yielding 150 for each participant and 300 for both. Then, we calculate the correlation between P1 and P2 $r_{1\&2}$ by subtracting from 1.00 the ratio of the sum of squares for P1 and P2 combined, which was calculated to be 300, to the sum of squared difference, which is sum of D^2 and equals 228. Thus, we have:

$$r_{1\&2} = 1 - \left(Sum\frac{D^2}{300}\right) = 1 - \left(\frac{228}{300}\right) = 0.24$$

The rest was calculated in the same manner and resulted in the following matrix:

Table 5 Correlation matrix

Part. No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
1	1.00	-	-	-	-	-	-	-	-	-	-
2	0.24	1.00	-	-	-	-	-	-	-	-	-
3	0.33	0.72	1.00	-	-	-	-	-	-	-	-
4	0.11	0.48	0.37	1.00	-	-	-	-	-	-	-
5	0.69	0.28	0.39	0.14	1.00	-	-	-	-	-	-
6	0.29	0.47	0.37	0.73	0.25	1.00	-	-	-	-	-
7	0.71	0.17	0.33	0.17	0.84	0.24	1.00	-	-	-	-
8	0.72	0.25	0.35	0.24	0.84	0.31	0.89	1.00	-	-	-
9	0.59	0.13	0.5	0.32	0.65	0.44	0.69	0.72	1.00	-	-
10	0.48	0.17	0.10	0.48	0.43	0.54	0.53	0.49	0.71	1.00	-
11	0.65	0.17	0.11	0.27	0.65	0.44	0.65	0.69	0.78	0.66	1.00

As stated by Brown (1993), for a correlation to be considered substantial, the correlation indicator must exceed 2.5 times of the standard error SE, which is $1/\sqrt{N}$ where N is the number of statements. In this case, the SE = $1/\sqrt{41}$ = 0.156, so to be considered substantial, the correlation between any 2 participants must be at least ±0.39.

b. Factor extraction with centroid analysis

Factor analysis was conducted via KenQ analysis tool, which extracted a total of 8 factors via centroid factor analysis from the correlation matrix.

Table 6 Unrotated Factor Matrix

Part. No.	**Factor 1**	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**	**Factor 7**	**Factor 8**
1	0.7243	0.2614	0.0775	-0.1642	0.0272	0.1455	0.0451	0.0866
2	0.443	-0.6055	0.2838	-0.241	0.0591	0.1937	0.0877	0.0329
3	0.4491	-0.4492	0.1253	-0.4914	0.3054	0.18	0.0757	-0.1704
4	0.4803	-0.5093	0.1745	0.3468	0.1139	-0.042	0.0033	-0.2786
5	0.7859	0.2745	0.0849	-0.3054	0.096	-0.0727	0.0102	0.0547

6	0.6037	-0.4251	0.1086	0.3706	0.133	0.0657	0.0085	-0.1249
7	0.7928	0.3828	0.1613	-0.2179	0.0476	-0.2546	0.2022	-0.0565
8	0.8453	0.2892	0.0936	-0.2067	0.0428	-0.1487	0.0466	-0.0289
9	0.7698	0.3327	0.1219	0.2975	0.0805	-0.0839	0.0138	0.1385
10	0.6873	0.0373	0.0041	0.4152	0.1754	-0.0716	0.0098	0.1208
11	0.7698	0.2997	0.0999	0.213	0.0387	0.0877	0.0155	0.1912

As mentioned above, **Table 6** represents the extent to which each participant's Q sort configuration correlates with each factor and serves as basis for factor rotations. **Table 7** shows the factors ordered by the total variability explained, meaning the first factor summarize most of the variance in the correlation matrix (Zabala, 2014). Next, as described in section VII.1.e, factors were selected for rotation to obtain a clearer and simpler structure of data on the basis of eigenvalues being larger than 1. The eigenvalues for each factor were calculated by the KenQ analysis tool as follows:

Table 7 Eigenvalues for each factor

	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**	**Factor 7**	**Factor 8**
Eigenvalues	**5.1361**	**1.5843**	0.2113	**1.0739**	0.1802	0.2092	0.0592	0.2082
% Explained Variance	47	14	2	10	2	2	1	2

Factor 1, 2 and 4 has eigenvalues larger than 1.00 and thus were kept for factor rotation with varimax applied.

c. Factor rotation with varimax applied and factor loading

Participant configuration's loading factor was then considered, the most representative Q-sorts for each factor are flagged. The basis for flagging follows 2 criteria:

- The loading l should be significantly high, larger than the significance threshold for a p-value < 0.05, which is given by $l > \frac{1.96}{\sqrt{N}}$ where N is the number of statements

(Brown, 1980, cited in Zabala, 2014). In our case, for a factor to be flagged, its loading must be larger than $\frac{1.96}{\sqrt{41}} = 0.3061$.

- Each configuration can only be flagged once with higher factor loading being prioritized.

Those with significant loading factor for each factor are auto flagged at $p < 0.05$ for rotation and generating output. The flagged configuration is highlighted in **Table 8**, only these Q-sorts are used for subsequent calculations

Table 8 Factor Matrix with Defining Sorts Flagged

Part.No.	**Factor 1**	**Factor 2**	**Factor 4**
1	***0.7619***	0.1682	0.1266
2	0.0747	***0.7594***	0.3342
3	0.2044	***0.7801***	0.0709
4	0.0368	0.3078	***0.7361***
5	***0.8462***	0.2697	0.0476
6	0.1728	0.2592	***0.7726***
7	**0.903**	0.1605	0.0724
8	***0.8833***	0.2172	0.1441
9	***0.7533***	-0.1496	0.4615
10	0.4864	-0.0776	***0.632***
11	***0.7489***	-0.0786	0.4123
%Explained Variance	39	14	19

The results of factor rotation and loading by KenQ analysis gave us the general characteristics of the factors (Table 9), which included: the number of defining variables (the number of flagged Q-sorts), the average reliability coefficient, and the standard error (SE) of factor scores. Figure 15 shows 3 factors' z-score for each statement, representing how each perspective weights each statement differently and how much they agree with the statement.

Table 9 Factor Characteristics

	factor 1	**factor 2**	**factor 4**

No. of Defining Variables	6	2	3
Average Reliability Coefficient	0.8	0.8	0.8
Composite Reliability	0.96	0.889	0.923
Standard Error of Factor Z-scores	0.2	0.333	0.277

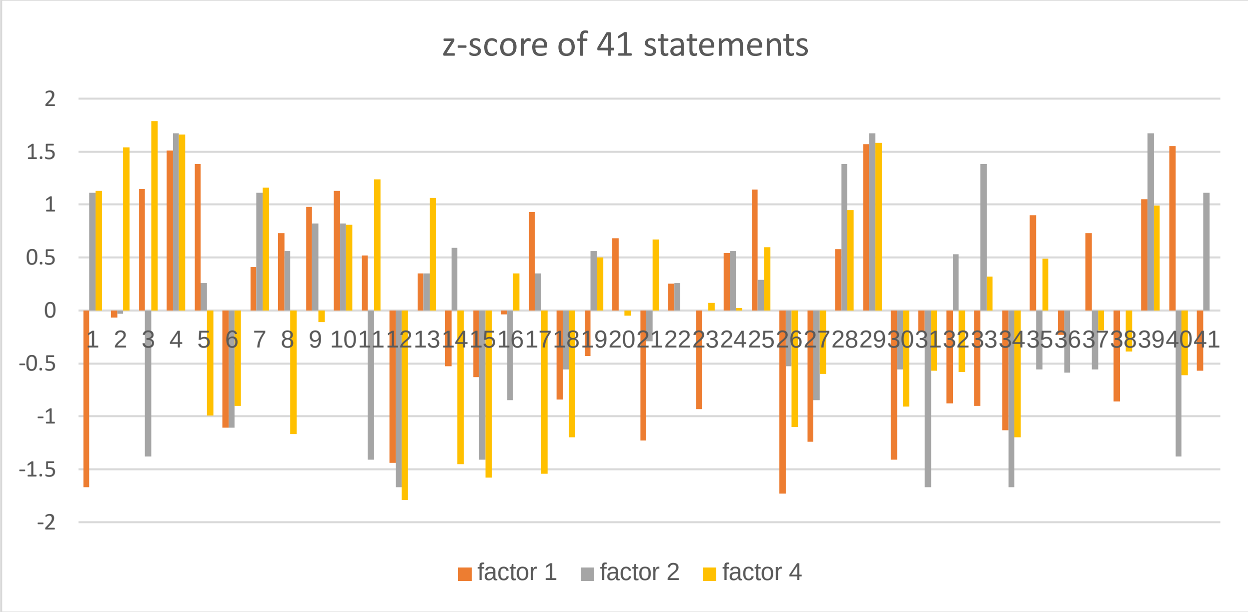


Figure 15 Z-score of 41 statements

Finally, we can extract the consensus and distinguishing statements for each factor representing a unique perspective shared by 2 or more stakeholders regarding *onsen hatsuden* development at Yuuyama, As stated by Zabala (2014), for each pair of factors, if the difference between the z-scores of a statement is statistically significant (based on the SE difference), then what both factors think about that statement is distinct. When none of the differences between any pair of factors are statistically significant, then the statement can be considered of consensus. Distinguishing statements are particularly important to interpretation as they most represent the perspective, therefore these statements would be listed in tables and serve as basis for interpretation. At the same time, consensus statements represent what all perspectives agree on. The next section outlines the factors identified where the configuration of statement number for each factor is visually represented in the pictures and tables of statement numbers (the statements are partially omitted for the sake of presentation in Figure 16, Figure 17 and Figure 18).

4. Factors identified

Factor analysis of Q-sort data from this study on stakeholder perspective of *onsen hatsuden* development in Yuuyama yielded 3 perspectives. Each perspective has its own set of stakeholders who identify with it.

Table 10 Stakeholders and factors they identify with

Position	**Affiliate**	**Factor 1**	**Factor 2**	**Factor 4**
1. Manager	Geothermal Power plant	✔		
2. Environmental Specialist	Ministry of Environment (MOE)	✔		
3. Section Chief of conservation of hot spring	Beppu *Onsen* Section		✔	
4. Beppu city officer	Beppu Environmental Section		✔	
5. Representative	Onsen Cooperatives		✔	
6. Owner	Hot spring/ hotel			✔
7. General Manager, Geothermal power department	Kyushu Electrics	✔		
8. Deputy director	Renewable energy Research Center	✔		
9. Landowner	None	✔		✔
10. Local residents	None	✔		✔
11. Local residents	Cooperative representatives	✔		✔

Before going into details on the different perspective, the next section will discuss consensus statements, representing points shared by all the participants.

a. Consensus statements: *Onsen* as a regional resource

Table 11 Consensus statement

Statement No.	Statement	F1 Q-SV	F1 Z-score	F2 Q-SV	F2 Z-score	F4 Q-SV	F4 Z-score
4	Onsen has a long tradition, heavy cultural implication and thus is highly prioritized	3	1.51	3	1.67	3	1.655
6	In the decision process personal interests are given preference over project interests.	-2	-1.112	-2	-1.114	-2	-0.904
10	I make my decision based on my knowledge of hot spring generation	2	1.134	2	0.82	2	0.807
12	In Beppu, it is easy to hold a roundtable with everyone to make decisions.	-3	-1.436	-3	-1.67	-3	-1.792
18	Local residents should not have autonomy in deciding their energy sources	-1	-0.843	-1	-0.556	-2	-1.195
24	Concerns for environmental problems is low in Beppu	1	0.536	1	0.556	0	0.016
27	The green lobby has a strong influence on the government.	-3	-1.238	-2	-0.85	-1	-0.597
29	In Japan, we should improve the efficiency of hot spring usage	3	1.565	3	1.67	3	1.583
34	Local residents have the best knowledge about community energy needs.	-2	-1.134	-3	-1.67	-3	-1.195
39	I am well aware of the possible environment impacts of the plant	2	1.046	3	1.67	2	0.993

**All listed statements are non-significant at* $p > 0.05$

Across the 3 perspectives, there is one line of thinking that is shared across all stakeholders. That is the narrative of *onsen* as an important resource in the local region and should be used efficiently, evident through statement 4 *Onsen has a long tradition, heavy cultural implication and thus is highly prioritized* and 29 *In Japan, we should improve the efficiency of hot spring usage*. Participants were involved directly with the project, therefore, they had faith in their own expertise regarding *onsen hatsuden* and make their decisions based on their knowledge, as evident through statements 10, 39 and 34. At the same time, participants felt the impact from red tapes and inefficiency when it comes to communication, particularly when the government is involved. Statement 12, 24, 27 and 34 all highlight that particularly in Beppu, it is not easy to orchestra a project involving a plethora of stakeholders, especially when the environment and local resource like *onsen* is concerned. Due to the deeper historical and cultural links to hot springs usage compared to other regions, this situation could be unique of Beppu and might not be applicable to other areas of Japan where hot spring resource is not as abundant nor as culturally rooted.

b. Factor 1: Pro-*onsen hatsuden*

Composite Q sort for Factor 1

-3	-2	-1	0	1	2	3
The green lobby has a strong influence on the government.	*◄ The profit return is uncertain	The plant is not a profitable business	energy regulators should address the issue of energy	The plant should play a role in reviving the local region	I make my decision based on my knowledge of hot spring generation	**► I have the feeling that the ecologic cons and the power
In Japan, we should not limit the conventional energy sources	**◄ The community has not gained significance with the power plant	* The decision process was not complicated	*◄ Tourism aspect of the plant must also be considered	We have to produce as much energy as possible to meet our needs.	All stakeholders should be involved in ecision-making.	In Japan, we should improve the efficiency of hot spring usage
In Beppu, it is easy to hold a roundtable with everyone to make decisions.	I am satisfied with the current level of preparedness for unexpected	The technology implemented in the power plant is not sufficient	The initial investment cost is too high	*► the power plant would have positive effect on local economy	*► Local citizens hold the most power in decision making	Onsen has a long tradition, heavy cultural implication and thus is highly
**◄ The plant present a grave risk to the onsen source	Local residents have the best knowledge about community energy needs.	local residents should not have autonomy in deciding their energy sources	local government holds more power in decision making	Concerns for environmental problems is low in Beppu	I understand the mechanism and technology behind hot spring	**► The plant is a "win win" situation for everyone.
In Japan we do not have to produce more renewable energy.	*◄ there is no need for more hot spring generation (because we	In projects planned at national level, local interests are enough	The electricity for the municipality is secured with the Yuyama	We should enhance the energy efficiency (efficient	I am well aware of the possible environment impacts of the plant	The energy strategy should focus on how to protect our nature.
	In the decision process personal interests are given	the power plant is not a resource for tourism	I could not influence the results of the decision process.	* The whole political apparatus could work faster.	In the decision process my main motivation was to produce renewable	
			*◄ Comparing the project's electricity with the market price, the			

-3	-2	-1	0	1	2	3
27	32	*19	7	8	25	29
30	**33	**14	13	**37	10	**40
12	*23	41	22	20	39	4
**1	6	*15	16	28	9	**5
26	34	18	2	24	17	3
	*21	38	31	*11	35	
			36			

Figure 16 Configuration of statement number for Factor 1 (with visualization and table representation)

*: Distinguishing statement at p< 0.05

**: Distinguishing statement at p< 0.01

Note: the statements are partially omitted for the sake of presentation. Please refer to VI.1.b Table 2 Q set for the complete sentences

The first factor represents a positive attitude towards development of the *onsen hatsuden* power plant in Yuuyama. This perspective is apparent within the company, electric utilities, central government, landowner and a local resident's configuration.

Table 12 Distinguishing Statements for Factor 1

Statement Number	**Statement**	**factor1 Q-Statement Values**	**factor1 Z-score**	**Significance**
40	I have the feeling that the ecologic cons and the power production are well balanced.	3	1.55	*
5	The plant is a "win win" situation for everyone.	3	1.38	*
37	The power plant would have positive effect on local economy	1	0.73	*
11	The whole political apparatus could work faster.	1	0.52	
19	Comparing the project's electricity with the market price, the energy policy seems senseless.	-1	-0.43	
14	The decision process was not complicated	-1	-0.53	*
15	In projects planned at national level, local interests are enough considered.	-1	-0.63	
33	The community has not gained significance with the power plant	-2	-0.9	*
23	The profit return is uncertain	-2	-0.93	
21	There is no need for more hot spring generation (because we already have high percentage of geothermal power)	-2	-1.23	
1	The plant presents a grave risk to the *onsen* source	-3	-1.67	*

($p < 0.05$: Asterisk (*) Indicates Significance at $p < 0.01$)

From **Table 12**, we have distinguishing statements for factor 1, statements with scores that are unique to this perspective and most represent what people who share the perspective thinks. Statement 40 *I have the feeling that the ecologic cons and the power production are well balanced* has strongly resonates with the respondents. They share the consensus that despite the negative implications of *onsen hatsuden* on the environment, it is justified with the power it produces. This can be linked to *onsen hatsuden* being a cleaner source of energy compared to fossil fuels. Statement 5 *The plant is a "win win" situation for everyone* highlights the shared belief that *onsen hatsuden* provides all round benefits for the society. Statement 37 *The power plant would have positive effect on local economy,* is another positive significant idea that *onsen hatsuden* will bring economic prosperity to the region. Statement 1 *The plant presents a grave risk to the onsen source* shows that the people in general do not think that the *onsen hatsuden* will threaten the source of the hot springs.

The follow up interviews with participants also reviewed some extra insight into what the stakeholders expected out of the power plant. The company and landowner of the plant in particular believed that the plan can be a source of regional revitalization for Yuuyama.

> *"I believed the Yuuyama powerplant would not only benefit the ones involved, but also the Yuyama region. We can organize exchange events, create Yuyama branded products made with geothermal power and the powerplant would be the center of activities. There is so much we can accomplish"*

-Landowner

By using the steam or by products from the power plant, they had plan to add value added activities such as establishing an *onsen* within the nearby bamboo forest, selling dried fruit and vegetable, green house agriculture and so on. The fact that the region was aging rapidly with few residents also reinforced their belief in the power plant's role in revitalizing the local economy and interest in the region.

c. Factor 2: Critical of *onsen hatsuden*

Composite Q sort for Factor 2

-3	-2	-1	0	1	2	3
In projects planned at national level, local interests are enough	The plant is not a profitable business	* there is no need for more hot spring generation (because we	The energy strategy should focus on how to protect our nature.	In the decision process my main motivation was to produce renewable	The plant present a grave risk to the onsen source	Onsen has a long tradition, heavy cultural implication and thus is highly
**◄ The whole political apparatus could work faster.	The green lobby has a strong influence on the government.	In Japan we do not have to produce more renewable energy.	The initial investment cost is too high	Comparing the project's electricity with the market price, the	Tourism aspect of the plant must also be considered	In Japan, we should improve the efficiency of hot spring usage
In Beppu, it is easy to hold a roundtable with everyone to make decisions.	*◄ local government holds more power in decision making	local residents should not have autonomy in deciding their energy sources	** The plant is a "win win" situation for everyone.	Concerns for environmental problems is low in Beppu	*► The technology implemented in the power plant is not sufficient	I am well aware of the possible environment impacts of the plant
*◄ The electricity for the municipality is secured with the Yuyama	In the decision process personal interests are given	In Japan, we should not limit the conventional energy sources	We have to produce as much energy as possible to meet our needs.	**► I am satisfied with the current level of preparedness for unexpected	I make my decision based on my knowledge of hot spring generation	We should enhance the energy efficiency (efficient
Local residents have the best knowledge about community energy needs.	**◄ All stakeholders should be involved in ecision-making.	*◄ The plant should play a role in reviving the local region	The profit return is uncertain	Local citizens hold the most power in decision making	I understand the mechanism and technology behind hot spring	*► The community has not gained significance with the power plant
	I have the feeling that the ecologic cons and the power	the power plant would have positive effect on local economy	the power plant is not a resource for tourism	energy regulators should address the issue of energy	*► The decision process was not complicated	
			I could not influence the results of the decision process.			

-3	-2	-1	0	1	2	3
*****11***	36	**21*	25	8	7	4
15	**16*	26	22	19	1	29
12	27	18	*****5***	24	**41*	39
**31*	6	30	20	**32*	9	28
34	*****3***	**35*	23	13	10	**33*
	40	37	38	17	*****14***	
			2			

Figure 17 Configuration of statement number for Factor 2 (with visualization and table representation)

*: Distinguishing statement at p< 0.05

**: Distinguishing statement at p< 0.01

Note: the statements are partially omitted for the sake of presentation. Please refer to VI.1.b Table 2 Q set for the complete sentences

The second factor is most evident in the local government and the *onsen* cooperatives.

Table 13 Distinguishing Statements for Factor 2

Statement Number	Statement	factor2 Q-Statement Values	factor2 Z-score	Significance
33	The community has not gained significance with the power plant	3	1.38	
41	The technology implemented in the power plant is not sufficient	2	1.11	
14	The decision process was not complicated	2	0.59	*
32	I am satisfied with the current level of preparedness for unexpected problems happening in the plant	1	0.53	
5	The plant is a "win win" situation for everyone.	0	0.26	*
21	there is no need for more hot spring generation (because we already have high percentage of geothermal power)	-1	-0.29	
35	The plant should play a role in reviving the local region	-1	-0.56	
16	local government holds more power in decision making than central government regarding hot spring power plants	-2	-0.85	
3	All stakeholders should be involved in decision-making.	-2	-1.38	*
11	The whole political apparatus could work faster.	-3	-1.41	*
31	The electricity for the municipality is secured with the Yuyama power plant	-3	-1.67	

($p < 0.05$: Asterisk (*) Indicates Significance at $p < 0.01$)

From **Table 13**, we have distinguishing statements for factor 2. Among the distinguishing statements for factor 2 is statement 14 *The technology implemented in the power plant is not sufficient*, where people share the sentiment that the level of technology used in *onsen hatsuden* is lacking, in areas including efficiency of power generations and structural which affects comfort levels of respondents. Statement 5 *The plant is a "win win" situation for everyone* is another significant account where there are neutral or negative annotations on whether the plant brings benefits for all stakeholders involve. Statement 3 is reflective of the respondents view that there more stakeholders should be involve in the development process, which they believe is insufficient now. Statement 11 shows significant views of how the process could be streamlined to be much speedier, which is not currently reflective of the current situation at the moment.

The government generally took a critical stance towards *onsen hatsuden* as they served as the middle ground between the *onsen hatsuden* developer and the local people. Although they fully understood the positive effect the plant could have on the local economy, they also had to carefully consider the negative impacts the plant might have, which was possibly followed by dissent from the local community, particularly the *onsen* cooperatives whose voice are among the fiercest when it comes to protecting the traditional usage of hotspring.

> *"We completely understand the importance of renewable energy and support policies in favor of its development. At the same time, however,* onsen *is an important resource that is owned and shared among the people of Beppu, thus its usage is not limited to geothermal energy. Conflict would arise if we are not careful when acting as the mediator between those sharing the same resource. Therefore, we must maintain a neutral and critical ground with regards to* onsen hatsuden*."*

-Local government official

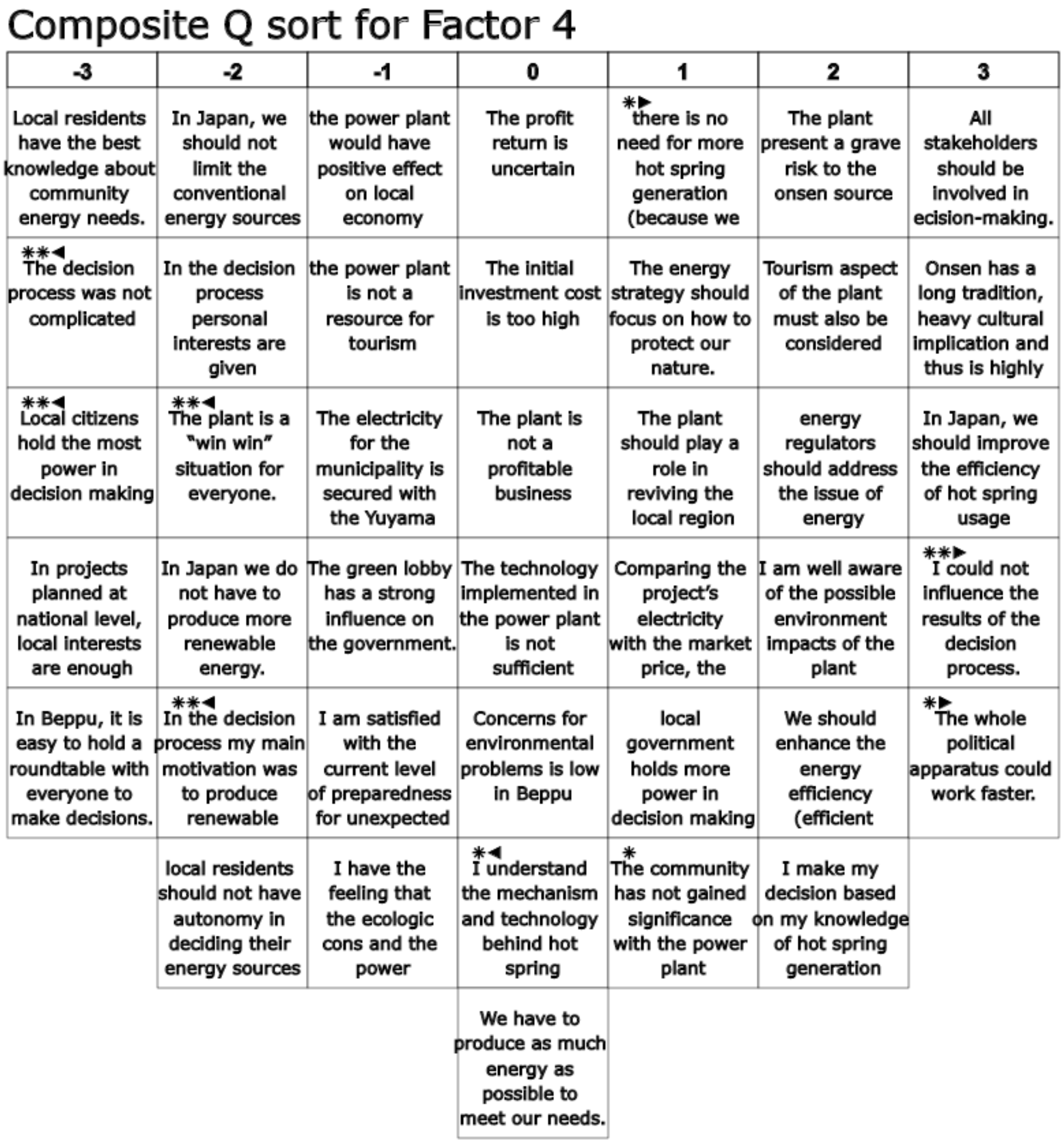
There are several ways in which dissent can lead to an unfavorable situation for setting up a new power plant. Local residents could go on strike or report their disapproval to the local government, which would put an end to the project, as participant 1 recounted from his experience.

"There was a case where local people organized a strike in front of the site for a powerplant, obstructing construction from taking place in another prefecture. In the end, the plant had to be put on an indefinite halt until the conflict was resolved. We do not want the same situation happening to Yuuyama, thus we highly prioritized making peace with the local people."

-Manager

There also existed a tension between the local and central government's goal and policy when it comes to development of *onsen hatsuden*. There seemed to be a perceived focus on renewable energy from the side of the central government, but local policy makers put more emphasis on preserving the *onsen* source, which *onsen hatsuden* could be considered as another source of stress for the resource. Juggling between the national goal of increasing renewable energy and the local policy of preserving the traditional values of *onsen* put the local government in a position where they had to be vigilant and critical when it comes to *onsen hatsuden*. Because of this tension and difficult position, involvement of multiple stakeholders in the decision process often resulted in prolonged discussion to gain results, thus this was generally negatively perceived, as indicated by statement 3.

d. Factor 4: Critical of decision-making process in *onsen hatsuden*



Composite Q sort for Factor 4

-3	-2	-1	0	1	2	3
Local residents have the best knowledge about community energy needs.	In Japan, we should not limit the conventional energy sources	the power plant would have positive effect on local economy	The profit return is uncertain	*▶ there is no need for more hot spring generation (because we	The plant present a grave risk to the onsen source	All stakeholders should be involved in ecision-making.
**◄ The decision process was not complicated	In the decision process personal interests are given	the power plant is not a resource for tourism	The initial investment cost is too high	The energy strategy should focus on how to protect our nature.	Tourism aspect of the plant must also be considered	Onsen has a long tradition, heavy cultural implication and thus is highly
**◄ Local citizens hold the most power in decision making	**◄ The plant is a "win win" situation for everyone.	The electricity for the municipality is secured with the Yuyama	The plant is not a profitable business	The plant should play a role in reviving the local region	energy regulators should address the issue of energy	In Japan, we should improve the efficiency of hot spring usage
In projects planned at national level, local interests are enough	In Japan we do not have to produce more renewable energy.	The green lobby has a strong influence on the government.	The technology implemented in the power plant is not sufficient	Comparing the project's electricity with the market price, the	I am well aware of the possible environment impacts of the plant	**▶ I could not influence the results of the decision process.
In Beppu, it is easy to hold a roundtable with everyone to make decisions.	**◄ In the decision process my main motivation was to produce renewable	I am satisfied with the current level of preparedness for unexpected	Concerns for environmental problems is low in Beppu	local government holds more power in decision making	We should enhance the energy efficiency (efficient	*▶ The whole political apparatus could work faster.
	local residents should not have autonomy in deciding their energy sources	I have the feeling that the ecologic cons and the power	*◄ I understand the mechanism and technology behind hot spring	* The community has not gained significance with the power plant	I make my decision based on my knowledge of hot spring generation	
			We have to produce as much energy as possible to meet our needs.			

-3	-2	-1	0	1	2	3
34	6	37	23	*21	7	3
**14	30	38	24	25	1	4
**17	**5	31	22	19	13	29
15	26	32	36	35	39	**2
12	**8	27	41	16	28	*11
	18	40	20	*33	10	
			*9			

Figure 18 Configuration of statement number for Factor 4 (with visualization and table representation)

*: Distinguishing statement at p< 0.05

**: Distinguishing statement at p< 0.01

Note: the statements are partially omitted for the sake of presentation. Please refer to VI.1.b Table 2 Q set for the complete sentences

In this perspective, stakeholders such as *onsen* business owners and local resident expressed criticism towards the political apparatus and decision process when it comes to addition of *onsen hatsuden* in the region. There were 2 main factors behind their critics. The first was their own knowledge and experience with *onsen* as a local resource and *onsen hatsuden* as a way to utilize this resource. The stakeholder in this case did their own research on the negative impacts of geothermal power such as usage of the fresh water, depleting the *onsen* source and uncertainty when disaster happens, some of which may apply to *onsen hatsuden* depending on how the plant is designed. Secondly, there was a perceived power distance by the *onsen* business owners and local residents towards the stakeholders who are in the position to decide such as the government and the project owner. They often felt a sense of helplessness as they perceived that their voice was not well received and thus could not influence the decision-making process. The distinguishing statements below further illustrate these points.

Table 14 Distinguishing Statements for Factor 4

Statement Number	**Statement**	**factor4 Q-Statement Values**	**factor4 Z-score**	**Significance**
2	I could not influence the results of the decision process.	3	1.54	*
11	The whole political apparatus could work faster.	3	1.24	
21	there is no need for more hot spring generation (because we already have high percentage of geothermal power)	1	0.67	
33	The community has not gained significance with the power plant	1	0.32	
9	I understand the mechanism and technology behind hot spring generation	0	-0.11	
5	The plant is a “win win” situation for everyone.	-2	-0.99	*
8	In the decision process my main motivation was to produce renewable energy.	-2	-1.17	*
14	The decision process was not complicated	-3	-1.45	*
17	Local citizens hold the most power in decision making	-3	-1.54	*

($p < 0.05$: Asterisk (*) Indicates Significance at $p < 0.01$)

From **Table 14,** we have distinguishing statements for factor 4. Here general critics of decision process *onsen hatsuden* strongly resonate with statement 2 *I could not influence the results of the decision process,* which indicates the sense of helplessness from stakeholders who share this perspective when it comes to decision process. Of the three main stake holders, government, private corporations and local community, the people (local community) believe that there have limited effect on the verdict of the development of *onsen hatsuden*. While statement 5 *The plant is a "win win" situation for everyone*, 8 *In the decision process my main motivation was to produce renewable energy*, 14 *The decision process was not complicated*, 17 *Local citizens hold the most power in decision making* are among the statements that are not in consensus with the respondents. People feel that in statement 8: they either neutral or against the idea of producing renewable energy, 14: requires a more complicated vetting process and 17: the local community have limited influence in the process of *onsen hatsuden* development.

From the beginning, stakeholders who identify with this perspective were not convinced by the prospects of the powerplant, evident through statement 8, 9, 21 and 33. Furthermore, they felt that the decision would proceed even without their own input (statement 2) and the process of decision making was perceived as complicated and time consuming (statement 11 and 14), which only served to shake stakeholders' belief in the ones directly involved such as the local government, the investors and utilities owners, as well as in the efficiency and effectiveness of the decision process as a whole.

> *"We understand how these powerplants work and saying that geothermal power does not have adverse effect is completely wrong. We ask that the local government, the utilities company and the business owner to not underestimate us and acknowledge that fact."*

-Onsen cooperative representative

VIII. Discussion

This paper set out to answer the question "What are the stakeholder perspectives on hot spring power generation ?". Using Q methodology to investigate stakeholders of Yuuyama Geothermal Power Plant, 3 perspectives were identified. Firstly, there are stakeholders who are proponent of *onsen hatsuden*, recognizing the need for more renewable energy in Japan as well as seeing this as an opportunity to revitalize the local area. Secondly, there are stakeholders who are not the biggest supporters of *onsen hatsuden* and would readily put a stop to a project if they perceive a threat from the project. Finally, there are stakeholders who are more on the neutral point and generally maintain skepticism which stems from inefficient communication between parties. The finding here confirms what previous studies have found on the public opinion of geothermal power in general. As for the second question asking whether "the same stakeholder perspectives of geothermal power generation could still apply to hot spring power generation", although there is a distinction between *onsen hatsuden* and large geothermal power plants, from this study we have learned that stakeholders of *onsen hatsuden* still maintained some of the perception explained in section II.6.

One example is the concept of *onsen* as a *regional resource,* which was the one aspect that was consistent across all stakeholders and perspectives (Section VII.2.a). When going into details, there are 3 types of rights concerning hot springs: land use rights, drilling/well rights and geothermal water use rights (Beppu Environmental Section, 2017). The geothermal water rights are owned by the community who pools their money and pays to the local government. The land of the drilling site and the drilling rights maybe privately owned. In other words, although the company can hold the right to drill the area, the *onsen* resource itself is still owned by members of the local community and thus requires negotiation.

Considering the size of the *onsen* tourism industry, as well as the heavy culture implication of onsen, the main narrative when it comes to *onsen* is that, *onsen* is a regional resource, that is a resource owned by the local community, under local people's jurisdiction and generate values for the local region. In other words, *onsen* as a *regional resource* here encompasses both the resource and the activities associated with it. What is meant by preserving *onsen* as a regional resource mainly has to do with preserving the traditional *onsen usage*, protecting the *onsen resource* itself is one aspect in order to achieve that goal. This concept was held in high regards and preserving the regional values generated from the current usage of *onsen* resources was one of the top concerns for all stakeholders (Section VII.2.a). Particularly in region such as Oita Prefecture and Beppu, because of the regional resource narrative, how this resource is used is heavily influenced by local people who happen to mainly consist of long-standing traditional *onsen* business owner (Kubota et al, 2013). Usage of *onsen* resource for power generation by *onsen hatsuden* investors who are also looking to utilize the same resource would mean facing the immense pressure from *onsen* business owners and local people, which cannot be taken lightly. This confirms Kubota et al (2013)'s findings on the important role of *onsen* business owners and how conservative values and beliefs could result in negative perception of geothermal power generation and subsequently impact its the development.

This brings up an interesting discussion as even though the possible negative impacts by geothermal power plants such as noise, depletion of *onsen* source and contamination were often brought up and warried of, proven impacts by the current usage of hot spring resources (Section II.3.b) such as water level depletion, ecosystem alteration and river contamination were mostly glossed over nor really touched upon. This could be a strong argument for the case of *onsen hatsuden*, as integration of *onsen hatsuden* as part of cascade hot spring usage model would result in more efficient way of utilizing this resource, rather than perpetual plumbing and directly discharging excess *onsen* into the environment.

Comparing the distinguishing statements, particularly statement 5 "*The plant is a "win win" situation for everyone"*, stakeholders' view on whether the power plant would benefit every party involved greatly varies across the 3 identified perspectives, from strongly agree to strongly disagree. Although all stakeholders believed that they were well-equipped with knowledge of *onsen hatsuden* and its possible impact on the local environment and based their decision on that knowledge as indicated by the Q results and the consensus statements (Table 11 statement 39), each perspective still gauged the power plant's impact differently. This variance is due to asymmetric information, where the ones directly dealing with business negotiation such as the central government, business partners and the project owners, had more access to technical information, while local people were only exposed to summarized aspects of such details (Section II.2.d). This resulted in the difference in the level of knowledge possessed by the participants. Specifically, partners such as Kyushu Electrics and geothermal research center, central government had access to detailed technical knowledge of the project, as well as its complete EIA, thus were more inclined to express total support towards Yuuyama power plant. For local people and hot spring business owners, their knowledge was mostly based on self-researched knowledge of geothermal energy, whose negative effects did not completely apply to *onsen hatsuden*, thus their stance gravitated towards either neutral or skeptical of building a new power plant at the time.

The results indicate a rift in communication between the local residents, including local people, *onsen* business owners and *onsen* cooperative representatives, and the local government, the business investor and the utilities. On one hand, results from factor 4 indicated that the former group felt a sense of helplessness in the discussion of *onsen hatsuden* and showed distrust in the effectiveness of the political apparatus (Section VII.1.b Factor 4). On the other hand, when asked about the role of *onsen* business owners and local residents in development of *onsen hatsuden*, both the government and the company expressed the opposite of what was felt by the local people. The local government stated that local people's opinion was held in high regards and the company would go as far as saying the *onsen* business owners were in fact the most important deciding factor, without their consent, the plant would not have been built (Section VII.1.b Factor 2). At this point, it is clear that communication between stakeholders was tense and lacking, resulting in negative perception of both sides towards each other. For development of *onsen hatsuden*, especially when it has to do with confrontation from local people, there needs to be better communication from both sides in the decision process.

At the same time, the results also highlighted an inefficiency in communication that plagued the process of conducting a new project in the context of Beppu city. To ensure that Yuuyama power plant was well received, the company and local government had to communicate with the local people on well researched aspects of the plant's output and impact, reassuring that the *onsen* source would not be negatively affected, but better utilized by both generating power and as a communal bathhouse of the nearby community facility. Yet, participants all showed consensus that the decision-making process was hard to organize, required a lot of time-consuming procedures and communication between stakeholders. This issue extends beyond the scope of Yuuyama and Beppu city has since then made efforts to improve their policies on *onsen hatsuden* development, streamlining and tightening control over the overall processes.

Despite all the above, for the case of Yuyama, stakeholders were generally supportive, and no one completely disagreed with the decision to establish the new power plant. In this case, although there were certain issues perceived in communication, all stakeholders had a solid grasp on *onsen hatsuden* and the possible impacts of the plant. This led to them being able to identify by themselves whether the plant would have a negative impact on the local environment or play a part in revitalizing the local region. This knowledge along with well researched and designed plan helped getting the approval for the project from the stakeholders.

Finally, it is important for policy makers to not only facilitate efficient communication between stakeholders, but also supply them with the necessary knowledge and carefully conduct research and planning for the project.

IX. Conclusion

While Oita prefecture boasts the highest percentage of renewable energy production in Japan, with the main contributor being geothermal power and the majority derived from existing large scale plants (e.g. Hachoubaru Geothermal Power Plant with capacity of 110MW in the town of Kuju). Small scale (<500kW) binary geothermal power projects are increasingly rapidly, but still face opposition coming from local residents, particularly from *onsen* business owners, which can hinder their development. In order to further develop new sources of renewable geothermal energy, it is important to understand the perspectives of stakeholders such as local citizens and *onsen* business owners, as well as the government and partners involved on the subject. In this paper, the author investigated this matter through a case study of Yuuyama geothermal powerplant built in Beppu city, Oita Prefecture, in 2014 by tackling these two questions: "What are the stakeholder perspectives on hot spring power generation" and "do the same stakeholder perspectives of geothermal power generation still apply to hot spring power generation?"

Using Q methodology, the results showed that stakeholder perspective on *onsen hatsuden* can vary from positive to critical, while some showed dissatisfaction towards decision-making process in particular. Stakeholders can gravitate towards environmental protection and renewable energy, thus view geothermal energy as positive. At the same time, since geothermal energy uses the same resource, that is *onsen* water, stakeholders can view geothermal power development rather negatively, or be critical of the whole process. Clear planning and communication is thus required throughout the project to ensure it would not adversely affect the *onsen* source.

The results also showed that despite being differentiated, some aspects of stakeholders' perception of geothermal power generation still applied to *onsen hatsuden*, such as the common narrative among all stakeholders, that is viewing *onsen* as an important local resource, traditionally utilized, that must be protected. When it comes to utilizing this resource, the traditional use as *onsen* - in other words for bathing and recreational purposes - do not face as much resistance from local people, as this habit is rooted in the culture and the influence of the tourism sector in Beppu is substantial.

This research also had certain limitations, at it is based on a case study of a single power plant in Yuuyama, Beppu; thus, the results might not be applied to other cases. As mentioned above, due to the nature of the Q methodology, although the perspectives presented here certainly exist, the research does not cover every perspective existing in the population, nor how much of the population shares the perspectives found here. In this study, due to the nature of participant selection using the snowball sampling method, only participants who were directly involved in the decision-making process and could provide insider insights were selected. By happenstance, participating stakeholders did not include people who were completely against development of *onsen hatsuden*, so such perspective was not apparent in this paper's results. More research on cases where negative impacts are observed might shed more light on how stakeholder might react towards *onsen hatsuden* in such situation. Nevertheless, this paper's findings highlighted the importance of communication and community's role in the development of hot spring power generation. Gaining the community trust could mean a make or break situation when it comes to this subject. It is thus recommended for policy makers and investors in binary geothermal power to improve communication efficiency among all stakeholders and in particular with local residents.

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