Engineering Journal issn: 0125-8281

Article

Establishing a Management System and the Role of Civil Engineering Consultants for Early-Stage Geothermal Development in Japan

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Abstract. Japanese civil engineering consultants are in general responsible for managing the entire development process of a project across multiple stages and they engage in various activities depending on their expertise. Previously, the relationship with the local government and the regions was of a form of waterfall style ("waterfall method"), where the clients prepare specifications and the civil engineering consultants implement their works according to these specifications. However, in cases of development of renewable energy to make it a major power source, this relationship has shifted to a form of a more agile style ("agile method"), where the civil engineering consultants are required to be diverse, responsive, and deployable to reflect the recent volatility, uncertainty, complexity, ambiguity (VUCA) era. This study therefore focuses on early-stage social acceptance of the geothermal development process in Japan, and the sixth and seventh editions of PMBOK are referred to examine the diverse activities that contribute to solving the problems faced by local governments and regions where renewable energy is being developed. Finally, upon such discussions, directions and specifics for future management systems are proposed.

Keywords: Geothermal power, consensus building, regional development, stakeholder management.

ENGINEERING JOURNAL Volume 28 Issue 2
Received 4 July 2023
Accepted 21 February 2024
Published 29 February 2024
Online at https://engj.org/
DOI:10.4186/ej.2024.28.2.1

1. Introduction

In Japan, in the past, civil engineering consultants responsible for the development of renewable energy conducted technical surveys to determine the energy potential, develop consulting services for power plant construction, and develop administrative procedures for various applications. However, in recent years, civil engineering consultants have been participating in power generation projects, essentially coordinating with local governments and organizations in development areas, and forming ESG (environmental, social, governance) investment projects to expand the scope of their activities. Therefore, efforts are being made toward various business types [1].

1.1. Research Background

In October 2020, the Japanese government declared a decarbonized society to reduce greenhouse gas emissions to zero by 2050. Such movements are the current global trend. Among the different renewable energies, geothermal power generation is positioned as a base load power source, considering it is expected to produce stable outputs, such as hydroelectric power generation [2, 3].

However, Japanese islands are located on volcanic belts and experience frequent volcanic hot springs. The use of hot springs was documented at the beginning of the 8th century. According to the Ministry of the Environment, as of 2021, approximately 2,894 [4] hot spring resorts and a total of around 27,915 [4] hot spring sources exist in Japan. Therefore, Japan is one of the world's leading countries for geothermal resources.

Although Japan ranks third globally in terms of geothermal resource potential [5], after the United States and Indonesia, it faces various challenges in compliance with regulations, such as the hot springs law, natural parks law, forestry law, landscape law, electric utility law, building standards law, and fire services law. Such strict regulatory frameworks and conditions restrict geothermal resource development. According to Kubota (2012) [6], the major factors hindering geothermal development in Japan are legal and regulatory issues, economic challenges, development risks, and the need for social acceptance and consensus-building. In particular, the coexistence with hot spring resorts causes disagreement among local stakeholders owing to the depletion of hot springs and geothermal power developers [7]. Consequently, Japan's geothermal power capacity is ranked 11th worldwide [8].

Geothermal development faces significant challenges in achieving regional acceptance and consensus-building with neighboring hot spring users owing to the improper handling of underground resources in the area. Regional engagement, which includes stakeholder coordination by development companies, involves sensitive matters as well as secret information on each developer. Aono et al. (2019) [9] discussed consensus-building methods with the local community based on practical experience; however, such publicly-available academic case studies on this topic are limited. Additionally, processes and systematized management techniques to enable regional acceptance and enhance consensus building have not yet been established.

Civil engineering consultants working on geothermal development projects, either in collaboration with the project owner or as the project owner, must consider the challenges in the development area, local municipalities, and compliance with government policies. This requires the functions of an advisor and the capability to execute tasks such as stakeholder coordination, various application and permission procedures, fundraising, and management of the investigation, design, construction, operation and maintenance stages.

Geothermal development projects have distinct characteristics such that the development approach varies depending on the progress of the site investigation and the underground resource potential. The specifications for power-generation facilities constantly vary depending on the availability of hot water; therefore, the possibility of shifting from power generation to alternative uses, such as direct heat utilization, particularly when power generation becomes unfeasible, must be anticipated.

In the current era of volatility, uncertainty, complexity, ambiguity (VUCA), geothermal power generation is believed to encompass a particularly high degree of these uncertain elements. For projects with such characteristics, diverse capabilities and adaptability with an agile mindset are required, which are based on the principles outlined in the "Agile Software Development Manifesto" [10] and are commonly used in software development practices. This indicates the importance of prioritizing responsiveness to change over strict adherence to the predetermined plans.

This study examined the diversity of civil engineering consultants and their utilization of project management methodologies in consensus-building activities based on practical experiences in achieving regional acceptance for geothermal development. We explored the development of a practical management system through successful case studies by extracting the functions that civil engineering consultants should possess for the future expansion of their business scope.

The project management methodologies used in this study were obtained from the 6th [11] and 7th editions [12] of the widely accepted Project Management Body of Knowledge (PMBOK). The 7th edition, published in 2021, introduced the concept of obtaining outcomes through iterative agile execution, which is highly compatible with validating this study. Note that the conventional Waterfall approach, presented in the 6th edition of PMBOK, suggests that a project can fail if the initial requirements are misunderstood. Therefore, considering the characteristics of geothermal development and the need for coordination with power generation host communities and local municipalities, an agile mindset is crucial.

1.2. Review of Existing Research and Issue

Previous studies have incorporated project management methodologies into the field of geothermal development. Peketsa Mangi (2016) [13] discussed the concept of managing an entire project, from funding to construction, operation, and decommissioning, using the five processes of the PMBOK 6th edition (namely, initiating, planning, executing, monitoring and controlling, and closing). Similarly, George Ngomi (2017) [14] performed a study focusing on cost management in these five process areas. However, these studies do not mention the consensus-building stages.

According to Kuwako [15], consensus building is defined to be to guide the process from a state where no consensus has been reached to a state where consensus has been reached, and also to be "It is a problem-solving process that seeks better answers rather than one correct answer.", and as well, social consensus building has been defined to be "The process of acknowledging the existence of diverse opinions, exploring the underlying values of each opinion, sharing that information, and creating solutions". In this paper, therefore, the same definition of social consensus building is adapted in the same manner. The 5th edition of PMBOK is included in the reference book of the paper, and the contents are oriented to integrate consensus formation theory and project management, of which the main fields there are public works such as rivers, roads and landscapes.

Takada et al. [16] used a framework to achieve a structural understanding of the consensus-building process in social infrastructure development.

Geothermal development is not the same as other social capital improvement projects such as wind power, solar power and so on, because it involves the mining of the region's unique underground resources. In addition, geothermal development may affect the business management of hot spring users who own hot spring rights. In order to reach an agreement between the developers and the hot spring operators, therefore, it is necessary to take an approach [17] that shows concrete measures for coexistence of both of them, based on the uncertainty of achieving targets such as water (precipitation), heat (magma) and containers (reservoirs), and the recognition of difficulties of mining such resources.

In addition, one of the features of geothermal development is the developers are required to make the initial moves with limited information. A practical problem here is that no one knows which approach would be effective in the region, which is a practical problem. Moreover, introducing and implementing such methods as have worked effectively in one region would not necessarily lead to successful consensus building in another region, which is evident from the author's experience. In addition to building trust with the region, the process for consensus building requires a careful and courteous multifaceted approach based upon understanding of the balance in regional community as well as upon getting the community to understand the benefits and risks to be brought into the region. In other words, it is concluded that an adaptation to local circumstances in each region, like a custom made approach, is inevitable.

This study focuses on systematizing an effective process for improving local acceptance in the early stages of geothermal development based on practical experience to contribute to the promotion of geothermal power generation. Furthermore, it provides directions for building a management system and specific examples of the necessary content that can be useful for practitioners.

2. Practice Fields and Workshops

The geothermal development project in Myoko City, Niigata Prefecture, initiated in 2017, is a subject of practical research. We participated in the project as civil engineering consultants, and promoted activities such as building the business scheme, fundraising, and conducting resource potential surveys during the feasibility study phase. In the initial stages, we the project using our funds. This chapter discusses the operational methods for conducting consensus-building activities with the local community through workshops.

2.1. Practical Field and Background

Five hot spring sources and seven hot spring areas exist on the eastern side of Mt. Myoko in the Joetsu region of Niigata Prefecture, with 270 hot spring facilities in operation. This region involves numerous stakeholders; given that it is located within a national park, its natural environment and landscape must be sufficiently considered. Initially, understanding geothermal development, including that of the local municipality, and achieving prompt consensus formation was challenging.

To overcome these challenges, we organized an information-exchange platform called the "Geothermal Community College" to promote understanding among the local community, with civil engineering consultants being part of the project team. This workshop was implemented by establishing a framework, as shown in Fig. 1, utilizing central government subsidies. These subsidies were available to either geothermal developers or local municipalities, whereby the geothermal developer applied for and received a subsidy. The project was selected for a 3-y period starting in the fiscal year 2018, and as of 2023, council activities are still ongoing.

The authors were involved in the said project as a geothermal developer as well as investor. Originally, it is definitely ideal that a third party such as a public sector and its related organizations or nongovernmental organization like DMO (Destination Management Organization) should carry out consensus building from a neutral standpoint. Such a system, however, has not yet been constructed in many regions of Japan, and this is one of the factors that prevent geothermal development from progressing in Japan.

In this sense, this case is a good practice, from the viewpoint of a position to promote the geothermal

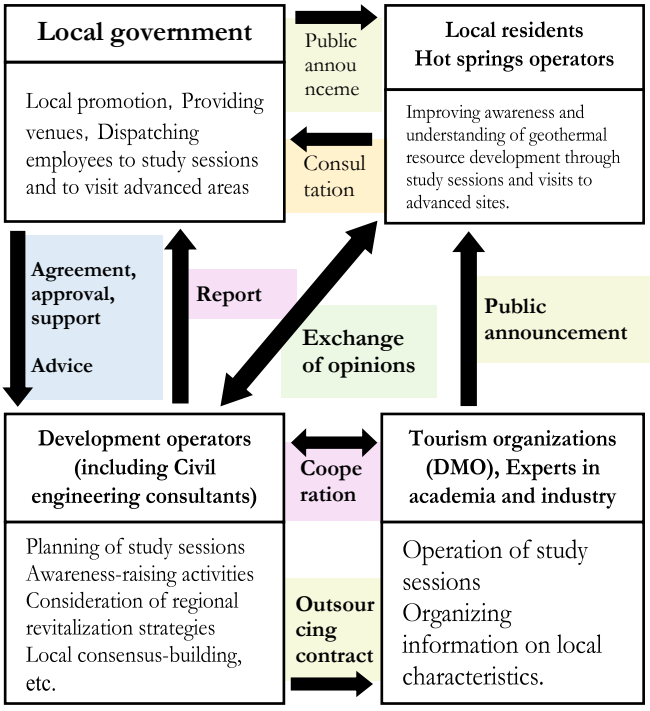

Fig. 1. Workshop implementation system.

development in such environment, introducing consensus building with the utmost consideration to the region.

2.2. Role Sharing and Approach Through Public–Private Partnership

To enhance awareness of the usefulness of geothermal energy, we sought the participation of knowledgeable experts affiliated with local universities and public research institutions and planned a workshop for the Geothermal Community College.

During operations, particular efforts were made by the Geothermal Community College to establish a close relationship with local government organizations. Important measures, such as city manifestos and municipal master plans, were understood in advance, and the benefits and risks of geothermal development projects were discussed to obtain the consent of the local government before initiating regional geothermal development. Additionally, clarification of the roles and responsibilities of project developers and local governments is crucial as they may vary between different projects.

Furthermore, by utilizing government subsidies and having civil engineering consultants participate as prosumers [18], working on projects includes strong incentives that are not limited to standard surveys and workshops. However, owing to changes in the natural conditions and situations inside and outside the region, the intentions of residents and local residents changes; therefore, inevitably, the agreed upon project plans will be reviewed. Furthermore, civil engineering consultants who are well-versed in local conditions must collaborate with local governments and propose regional promotion measures to resolve multiple specific regional issues.

Civil engineering consultants must formulate specific business plans, including funding, assuming that they will participate in development projects. In addition to conventional technical consulting tasks, they are required to handle various other aspects, such as entering into agreements related to the establishment of a special-purpose company (SPC), funding, permit applications, securing electricity buyers, and contract management. Therefore, expertise in fields such as finance, accounting, and law is necessary, in addition to technical expertise. Herein, we included professionals from diverse fields.

According to the 7th edition of PMBOK, in cases where the ultimate goal is unclear and the requirements are constantly changing, an "agile approach" that can respond flexibly is recommended. Civil engineering consultants should adopt iterative and collaborative team-based development approaches.

3. Building Implementation Organization and Implementing the Workshop（Geothermal Community College）

The Geothermal Community College, established in 2018, was planned according to the management methods described in the previous section. It aims to promote local consensus-building. The geothermal developer obtained consent from the seven hot-spring users and conducted a ground survey. In the fiscal year 2018, a basic survey was conducted to determine regional issues, and in the fiscal year 2019, regional development measures with high needs were implemented on a trial basis. In this chapter, we describe the practice history carried out in 2018 at the Geothermal Community College.

3.1. Establishment and Operation of Geothermal Community College as Execution Organization

As obtaining consent for a geothermal development project quickly is challenging, the stakeholders' understanding of geothermal energy must be improved to ensure they are aware of their participation in the Geothermal Community College and the geothermal development project. Herein, we planned multiple events with different themes.

The overall concept of the Geothermal Community College is to improve awareness and understanding of geothermal energy, and present proposals for utilizing hot water with reference to other consensus-building examples to improve momentum. Therefore, we thoroughly shared risks, such as possible impacts on the natural environment during the development process and cases of cancellations or interruptions in other regions. By presenting ways to avoid them, we eliminated anxiety and distrust. Business operators and local residents worked together to create a vision for the future of the area, which can lead to regional development.

DOI:10.4186/ej.2024.28.2.1

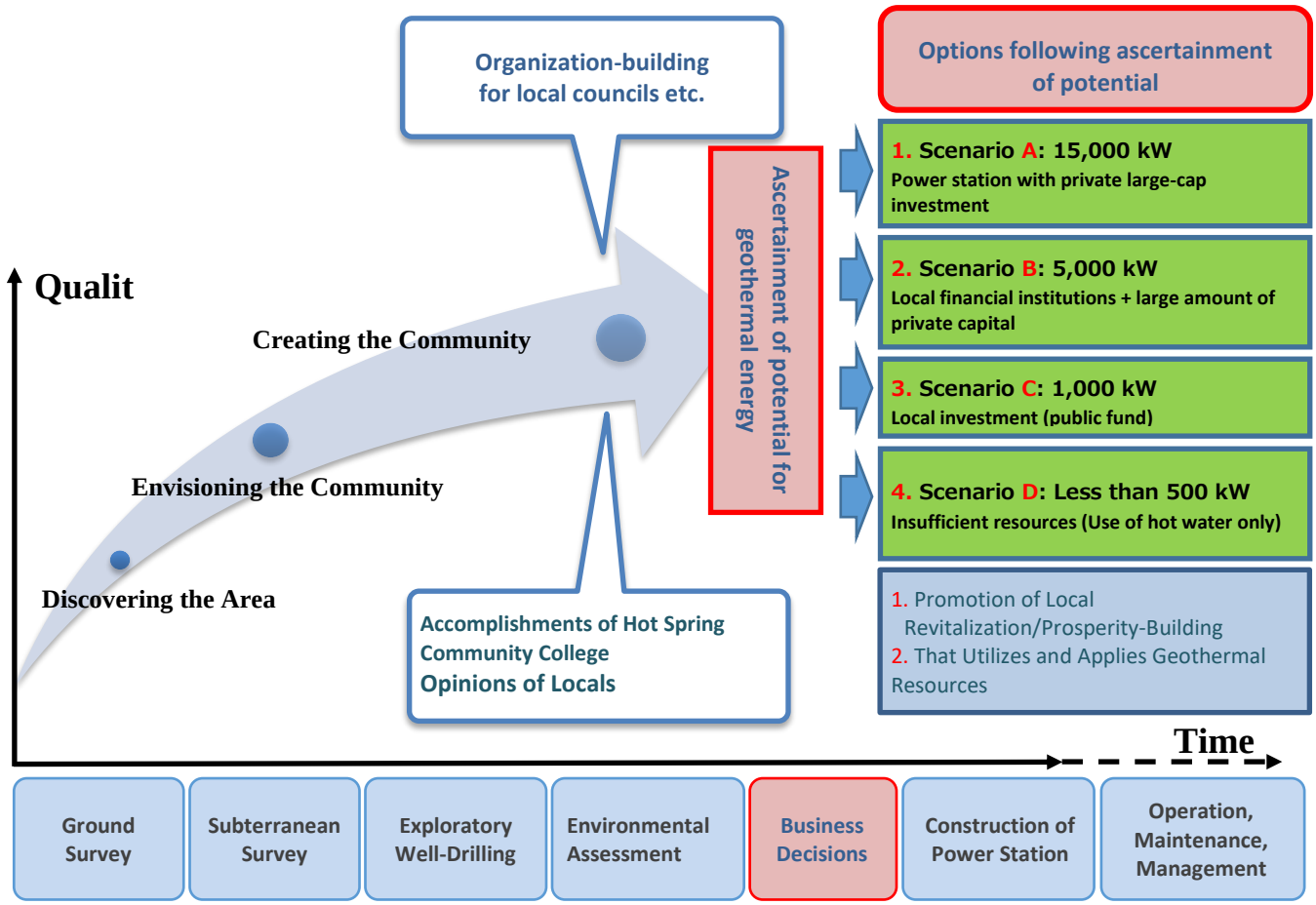

Fig. 2. Geothermal resource development scale and multiple scenarios.

Further, numerous stakeholders were anticipated to not participate in the workshops or oppose the project. Therefore, efforts were made to encourage participation through town mayors and influential local figures who expressed their intention to participate and avoid isolating the opposition. Additionally, a mechanism was established to provide information to stakeholders who were absent from the workshops. Sharing successful cases, cases of cancellations, suspensions, and challenges in project execution openly is crucial. Moreover, considering the high uncertainty in the early stages of geothermal development, where even developers themselves may not have a clear understanding of the resource potential (project scale), and multiple scenarios must be presented.

As mentioned above, in geothermal development, where there is a strong element of uncertainty, the progress of the project process is tend to be largely determined by the estimated amount of resources obtained through various geological surveys. Therefore, as shown in Fig. 2, the Geothermal Community College presented several scenarios with different amounts of resources, trying to build social consensus.

3.2. Workshop Practice Menu and Survey Results

Table 1 summarizes the four practices of the Geothermal Community College held in the fiscal year 2018. To assess the level of understanding of the promotion, a questionnaire using an anonymous format with preset questions was administered to local hot spring users participating in the three workshops and one field visit. The acquisition dates for the questionnaire responses were all in 2018 (3rd September, 2nd October, 21st November, and 13th December). Additionally, a comment column was provided for the participants to freely express their opinions.

Table 1. Geothermal Community College Menu for the Fiscal Year 2018.

Year	Schedule	Content
2018	3rd September	Current status and challenges in geothermal resource development and coexistence with hot springs
	2nd October	Introduction of regional activation examples utilizing surplus hot water nationwide
	21st November	Visit to agricultural facilities using surplus hot water
	13th December	Social and environmental harmony in regional resource development

The participation of hot spring users varied across the sessions, with 12 participants in the first session and 27 in the third session. As the sessions progressed, the number

of participants increased, thus indicating increased awareness and attention.

The questionnaire results shown in Fig. 3 on "Understanding of geothermal energy" reveal that on all event occasions except for the second, over 80% of the respondents answered that their understanding had deepened.

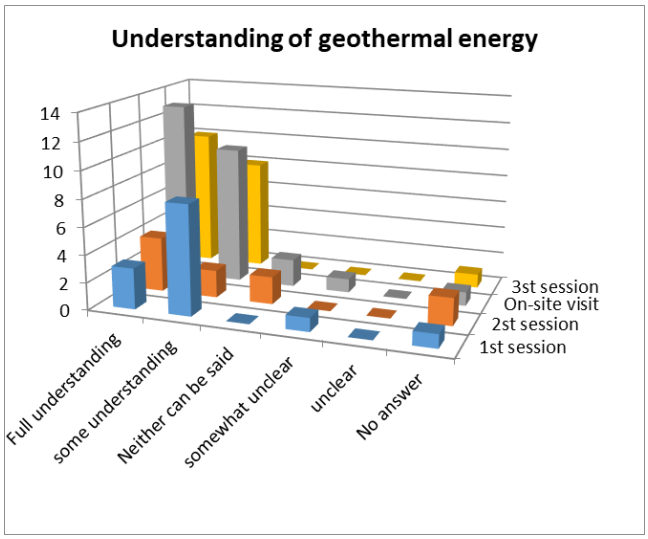

Fig. 3. Understanding of geothermal energy.

Figure 4 shows the awareness of geothermal development. Evidently, opposing responses were obtained from one participant each in the 1st and 3rd surveys. Nonetheless, all participants responded with "Agree" or "Neither agree nor disagree," thus indicating that the majority had a positive stance or were neutral toward geothermal development. The awareness of geothermal development fluctuated over time but ultimately shifted toward majority support.

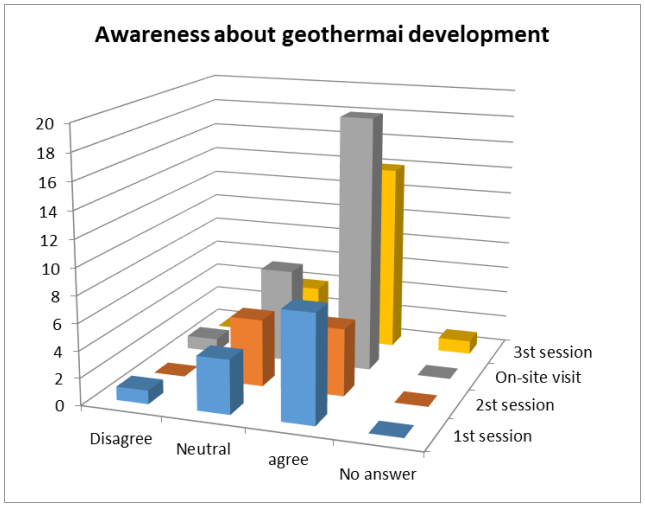

Fig. 4. Awareness of geothermal development.

However, in the comment section, responses such as "I'm not sure that there will be no impact on hot springs," with reasons such as "more hot spring users need to participate" and "the merits and demerits of the local community are not yet clear" were noted.

In the final questionnaire (Fig. 5), the majority of respondents indicated the need for "activities for the next year and beyond," and the comments expressed the desire to "think about regional development together." As no opposing views were noted, we achieved consensus and obtained consent letters from all hot spring associations involved in the vicinity of the field survey. In the fiscal year 2019, we successfully initiated surface surveys without excavation, including geophysical exploration. In the fiscal year 2020, a council was established and is still ongoing.

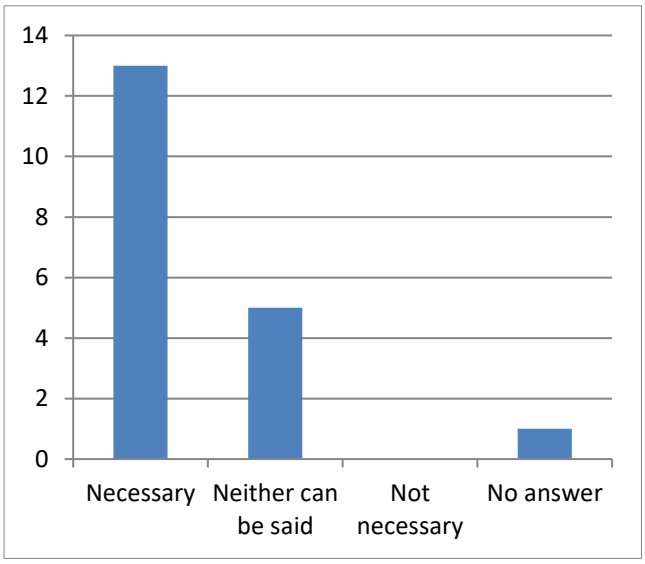

Fig. 5. Regarding activities for workshops in the following fiscal year

4. Diverse Civil Engineering Consultants' Responses

In this practice area, a regular liaison meeting has been established as of April 2023, and preparations are underway for an excavation survey scheduled for FY 2023. To promote consensus-building activities, this chapter describes the activities of civil engineering consultants who have a broad understanding of local conditions, including requests from local communities and coordination with local governments, rather than participation from the standpoint of providing only specialized technology.

4.1. Environmental and Local Situation Survey

First, we conducted research on regional resources, industrial structures, and traffic around the area. Simultaneously, we examined the issues and needs of the area and presented several regional development models based on collected statistical data and interviews with local residents and related organizations. In addition, we expanded the area of the survey to investigate regional issues and needs for each area, and organized regional promotion measures that utilize surplus hot water to solve

the problem. Moreover, by using the results of the survey as a draft at workshops and inspections, and accordingly conducting examinations and discussions with local companies and governments, regional development measures with high needs were compiled. For regional promotion measures that were confirmed to have high needs in these activities, we discussed and examined the requirements for business establishment in creating a business model, and evaluated and verified the business feasibility by referring to similar initiatives.

Additionally, we examined the organization and management system necessary for fair and impartial consideration of geothermal development while incorporating the opinions of the entire region, and identified the issues involved in constructing the system. Consequently, we established a liaison committee agreement to examine these three issues and build an implementation system shared by all stakeholders. The three items to be examined were geothermal resource development surveys, regional revitalization using surplus heat, and other related matters.

4.2. Examination and Extraction of Regional Promotion Measures

We conducted surveys targeting hot spring resorts in seven regions related to tourism and life issues in the area (such as via interviews with stakeholders, workshops, and inspections), and summarized the identified issues. The issues were broadly categorized into "Living," "Industry and Employment," "Tourism," and "Local Leaders/Funds." We further categorized them into common and individual issues, and compiled regional promotion measures that addressed the needs of each category of issues. Finally, we extracted the regional promotion measures with the highest needs and presented a geothermal energy utilization image map (Fig. 6). Moreover, we confirmed the consistency between local governments and policies.

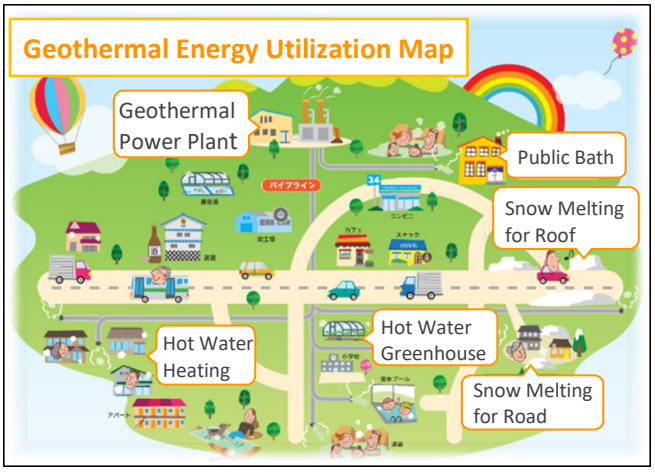

Fig. 6 Concept map geothermal energy utilization.

Consequently, in addition to the geothermal power generation project, multiple secondary regional development projects were implemented, as shown in Figs. (**4.3**)– (**4.6**).

4.3. Example 1 of Regional Promotion Measures (Agricultural Utilization)

During the 3rd workshop at the Geothermal Community College, we visited agricultural facilities that utilize surplus hot water, where we were introduced to a case study of edible flowers cultivated in greenhouses using hot water (Fig. 7). We received feedback from accommodation facilities in the area expressing demand for such products. We are currently evaluating a business venture that would utilize existing wells or newly obtained hot water.

Fig. 7. Study on Edible Flower Greenhouse.

4.4. Example 1 of Regional Promotion Measures (Use of Road Snow Melting)

In a survey conducted to understand the need for regional development measures, we obtained a request for the year-round use of a public open-air bath (Fig. 8) in a hot spring town, which is a popular tourist attraction that is closed in winter owing to snow. Thus, a snow-melting experiment (Figs. 9 and 10) was performed in an 80-m long section using hot water from an open-air bath. We successfully derived a fantasy space by incorporating the idea of lighting it up at night (Fig. 11).

Fig. 8. Public open-air bath.

Fig. 9. Pathway to a communal outdoor hot spring bath (during the summer season).

Fig. 10. Pathway to a communal outdoor hot spring bath (during the winter season).

Fig. 11. Pathway to a communal outdoor hot spring bath (Night light up).

4.5. Public Relations Activities Using Social Network Services

By holding workshops and liaison meetings in practice areas, we constructed and implemented a PR method using social network services (SNS), such as widely disseminating business explanations, holding events, deciding whether to participate, and answering questionnaires. It was constructed to enable complete participation by all stakeholders in their fields of interests and allow them to easily communicate their intentions. Although still in the demonstration stage, we confirmed an improvement in the number of participants and reactions before and after use.

4.6. Zero Carbon Action Plan

A large area around the practice area has been designated as a quasi-national park, and the local government has issued "Zero Carbon Promotion Declaration (June 2020) [19]," aimed at net zero carbon dioxide emissions, and "Zero Carbon Promotion Ordinance (April 2021) [20]." This area is also selected for the SDGs Future City/Local Government SDGs Model Project (May 2021) [21], which aims to create a sustainable city where people and nature coexist in harmony.

As civil engineering consultants participating in power generation companies, initially as a member of a development research project consortium, we began building relationships with local governments with self-financed geothermal development in 2017. We were commissioned by a local government to implement a "Zero Carbon Action Plan Formulation Work [22]" to study the introduction of renewable energy, which is a government policy.

This can be considered a by-product of the degree of familiarity with the region, at least through activities that collect information on the history, climate, politics and economy of the region, build relationships with stakeholders, and deepen the understanding and recognition of tacit intellectual human relationships in the region.

4.7. Expansion of Roles and Activities of Civil Engineering Consultants

A white paper on civil engineering consultants [23] emphasizes the importance of expanding the scope of activities for civil engineering consultants to address urban/regional revitalization that reflects socioeconomic conditions and the new normal decentralized society. It also reports that "business execution support that utilizes knowledge in a wide range of fields, such as legal affairs, labor affairs, and finance, is required." In this case, various activities were carried out, and personnel with specialized knowledge were assigned to handle individual projects. From the initial stages of consensus-building activities, a diverse approach combining project management knowledge and flexible agile thinking is essential.

5. Verification Method for Project Management Method and Initial Consensus Building Activity

As mentioned above, we aim to provide knowledge and means for verification using the PMBOK, consensus-building activities for local acceptance of geothermal development, where the form of development can change depending on the results of technical surveys and the wishes of residents. We decided to use both the 6th edition, which is based on knowledge, and the 7th edition, which

presents only a comprehensive theory of principles that incorporates agile thinking.

In the initial stage of the project, before contacting the local people, we had limited information for planning. In this case, the most useful reference is "stakeholder management" in the 6th edition of the PMBOK. In addition to the four processes of initiating, planning, executing, and monitoring and controlling, it is divided into five parts: closing and each process has three parts (inputs, tools and practices, and outputs). According to the definition of PMBOK, we first referred to these five activities to determine what should be created and managed in which process. Next, we created a waterfall model that associates each of the five processes with activity policy tools and practical techniques. Figure 10 illustrates the workflow diagram.

Furthermore, based on the proposed activity policy and considering the practical implementation of consensus-building activities in this case, we confirmed the compatibility of Waterfall in **5.2** and Agile in **5.3**.

5.1. Planning Consensus Building Activities

When constructing the activity policy flow for consensus-building, we classified the activity contents by referring to an overview of the 6th edition of PMBOK. Figure 10 shows a consensus-building workflow diagram associated with the PMBOK. The activities in each process are defined as follows.

First, stakeholders were identified during the initiating process, and coordination with local governments was ensured. However, when the opinions of the local community have not been sufficiently collected, understanding and responding are challenging. Therefore, in the activity policy workflow (Fig. 10), soundings (interactive surveys) and small-scale workshops with the local community were conducted in the planning process.

Voluntary understanding promotion conducted in the planning process refers to activities that are voluntarily implemented by the operators using their own funds, rather than relying on subsidies or grants.

The small-scale workshops in the execution (management) process were limited to a small number of participants and a single specific region (hot spring town). Medium-scale workshops that use subsidies were held jointly in two or more regions. After the workshops, councils or liaison meetings were established during the monitoring and controlling process.

In voluntary medium-scale workshops during the execution (management) process, the technical aspects (such as the characteristics of geothermal energy, geothermal power generation technologies, their comparison with other power generation methods, and the potential risks to the natural environment), as well as softer aspects (such as possible sources of funding, forms of project implementation, the importance of local organization participation, and the establishment and operation of councils or liaison committees as decision-making processes) must be explained.

Basic policy proposal for activities toward consensus building		PMBOK Stakeholder management Overview
■Local government involvement ■Identification of Key Stakeholders ■Grasping of local social conditions	Initiating	1. Identifying stakeholders
■Self-financed promotion of understanding ■Sounding for locals ■Small workshop	Planning	2. Preparing for stakeholder management
■Small workshop ■Sounding for locals ■Medium workshop	Executing	3. Implementation of stakeholder management
■Promotion of understanding ■Medium-sized council	Executing	4. Stakeholder engagement and management
■Promotion of understanding ■Council implementation	Monitoring and controlling	5. Monitoring Stakeholder engagement Control
■Development and construction agreement ■consensus building	Closing	Steering committee

Fig. 10. Workflow associated with the 6th edition of PMBOK.

In the closing process, the final consensus is reached within the Steering Committee (operational committee within the organization).

A step-by-step explanation was provided in a workshop-style workshop using subsidies, and a flow for collecting opinions while promoting an understanding of geothermal energy among the stakeholders was planned. (Fig. 10.)

5.2. Consistency of Waterfall-type Consensus Building Activities

According to the 7th Edition of the PMBOK, construction and manufacturing industries are generally suitable for the waterfall-type method, and developers and customers agree on what to provide at an early stage, thus making planning and design easier. It is also considered suitable for progress management because the entire picture of the work can be known in advance. However, note that evaluations are conducted according to individual projects and situations.

Waterfall type is a process that emphasizes stability by accurately grasping the customer, without major changes in the scope and without the possibility of changes

throughout the project life cycle, such as contracts with government agencies. It has a high affinity for the workflow of conventional civil engineering consultants. However, applying it to consensus-building for geothermal development is challenging as it requires various responses and will be reviewed repeatedly, including revision of the project scope itself. Essentially, in the initial stage, a baseline plan is created, similar to the waterfall method; however, it must be sufficiently flexible to anticipate major policy changes. The 6th edition of the PMBOK also mentions changes in the scope of the project in the section on integrated change management. In the integrated change management data flow diagram presented in this book, the plan documents related to all knowledge areas formulated in advance are changed, and the change control board (CCB) approves or rejects them. A detailed baseline plan for a project that is suitable for the complete waterfall method must be created; however, in the consensus-building stage of geothermal development, a wide range of plans that consider the development of multiple scenarios must be developed. Simultaneously, the functions of the CCB must be ensured in organizational construction.

5.3. Consistency of Agile-type Consensus Building Activities

According to the 7th edition of the PMBOK, the agile method is suitable for software and website development; if the final goal is unclear and the requirements are constantly changing, the agile method is suitable. Therefore, we believe that the advantages of agile and waterfall types must be incorporated into consensus-building activities during the initial geothermal development.

6. Building a Management System based on Agile Thinking in the Initial Consensus Building Stage

As mentioned in the previous section, when the project management method was applied to our initial consensus-building activities, each process management for consensus-building involving civil engineering consultants used the knowledge areas of the 6th edition of the PMBOK. Moreover, the 7th edition's agile method-centered way of thinking was also found to be suitable.

However, several concerns regarding the implementation of the agile method, in that it may lead to a lack of planning" or ad hoc "activities, exist. To allow civil engineering consultants to conduct similar activities efficiently in the future, these must be systematized into a business management system that incorporates agile thinking. Therefore, we attempted to systematize the tangible and intangible insights gained from our activities as management systems (see Table 2).

The scope of our activities, as the authors focus on consensus-building in the early stages of a project, and the knowledge area that aligns most closely with our activities is stakeholder management in the 6th edition of the PMBOK. In practice, we encountered situations where the goals of stakeholder management activities continued to shift. To address this, we believe that incorporating elements of value delivery, iterative decision-making, and execution (sprints), and review and evaluation based on the Agile principles of the 7th edition of PMBOK would make our approach more practical. In the future, we plan to develop a management system consisting of procedural documents and templates that outline these specific steps.

Table 2 presents the construction of each management system that includes tools used in actual projects, including the case studies. These tools comprise letters, forms, agreements, and report templates. By generalizing these tools and eliminating specific elements unique to individual cases, we aim to create standardized resources. This will reduces the burden on practitioners and allow them to focus on improving local acceptance, which is the core objective of their work. As the number of projects we participate in increases, the management system is expected to improve further.

This paper describes the construction of a system that focuses on stakeholder management planning, including the implementation of stakeholder management (implementation of workshops) among the initial consensus-building activities, and presents the contents of general consensus-building activities based on practice. Table 2 presents an example of the business system that was developed.

7. Discussion and Summary

This study examined consensus-building activities to improve the local acceptance of geothermal development, which is part of the expansion of the scope of activities for civil engineering consultants. The compatibility between these activities and project management methodologies using both the 6th and 7th PMBOK editions was confirmed based on practical applications.

The conclusion highlights the need for a thorough understanding of agile methodology, which has undergone significant changes in the 7th edition of the PMBOK. Furthermore, this study presents considerations and challenges aligned with the characteristics of agile organizations.

7.1. Response by Flat Organization

In the agile method, organizations with decentralized authority, even small-scale organizations, can have diverse members, each of whom can hold a certain authority, thereby creating a structure that is conducive to understanding customer needs and allowing opinions to be expressed regardless of age or position.

Table 2. Business system for consensus building activities.

Code	Category	The role and duties of Civil Engineering Consultants	Checklist by Civil Engineering Consultants	Document formats
	1. Management plan			
1- 1	Statistical analysis of census data	Organizing census data	Are you able to understand the characteristics of the local area?	Population and industry analysis
1- 2	Literature review	Confirming historical and cultural literature	Can you grasp the unique culture of the region?	Regional cultural research
1- 3	Existing data investigation	Confirming existing technical materials	Is there any history of past planning and survey investigations?	Estimated resource volume
1- 4	Simple surface survey	Checking hot spring well ledger	What is the potential for resource development?	Geological overview
1- 5	Verification of municipality websites	History of renewable energy introduction plan	Is there a willingness to actively pursue renewable energy?	Verification of municipal publicity
1- 6	Overview of city government	History of renewable energy introduction plan	Is there an understanding of renewable energy?	Matching of policy vision
1- 7	Confirmation of election results	Checking results of mayor and council elections	Have you confirmed any political risks?	Confirmation of political risk
1- 8	Question manual	Creating a list of questions	Are the questions being asked sincere?	Questionnaire draft
1- 9	Answer example manual	Creating examples of answers	Are there any problematic answer examples?	Response draft
1- 10	Understanding of implicit knowledge in human relationships	Confirming local organizations	Are there any omissions in the confirmation?	Correlation diagram
1- 11	Priority ranking of visit destinations	Confirming human relationships	Is the visit order correct?	Correlation diagram
1- 12	Creation of a stakeholder correlation diagram	Creating correlation diagrams	Are all related hot spring businesses covered?	Correlation diagram
1- 13	Confirmation of intentions with local governments	Conducting hearings	Have you grasped the responsible parties?	Questionnaire draft
1- 14	Hearing items for relevant ministries and agencies	Understanding subsidy application forms	Does it meet the criteria for applying for subsidies?	Meeting agenda
1- 15	National policy project through acquisition of subsidies	Providing advance notice to department officials	Is the project recognized?	List of relevant subsidies
	2. Implementing management			
2- 1	Benefits examples from advanced regions	Organizing examples of benefits	Does it align with the target area?	Advanced regional benefits examples
2- 2	Creation of an image map	Creating an image map	Is the created image map feasible?	Image map
2- 3	Preparation of multiple scenario proposals	Preparing multiple scenario proposals	Does it present scenarios that benefit the region?	Multiple scenario ideas
2- 4	Adherence to individual visit priorities	Conducting individual visits	Is the visitation order correct?	Correlation diagram image
2- 5	Visit to the mayor and greetings	Individual visits and greetings	Does it demonstrate the benefits to the local government?	Mayor's visit agenda
2- 6	Announcement of study sessions	Preparing for a study session	Are there any omissions in the announcement?	Announcement example
2- 7	Dissemination of individual (regional resource) values	Preparing and distributing study session materials	Does it deepen the understanding of geothermal energy?	Study session distribution material example
2- 8	Questionnaire question items	Preparing a questionnaire draft	Are the questions aimed at uncovering the truth?	Questionnaire example
2- 9	Successful and unsuccessful examples from advanced regions	Organizing benefits and risks	Does it stir up unnecessary anxiety?	Study session distribution material example
2- 10	Utilization of government's expert dispatch system	Understanding the specialist dispatch system	Are appropriate specialists selected?	National dispatch system
2- 11	Analysis of questionnaire results	Summarizing questionnaire results	Are fair interpretations made?	Survey results
2- 12	Preparation of template for requests	Creating a request letter	Does it provide benefits for the region?	Request form template example

2- 13	Information sharing of hot spring monitoring results	Organizing results of hot spring monitoring	Are accurate information being conveyed appropriately?	Monitoring results example
2- 14	Consolidation of opinions for individual requests	Aggregating opinions and organizing requests	Is accurate information being properly summarized?	Opinion aggregation example
	3. Engagement			
3- 1	Announcement of Study Session	Preparation of study sessions	Are there any notification omissions?	Example of a study session invitation
3- 2	Dissemination of (local resources) values individually	Preparation and distribution of study materials	Does it deepen understanding of geothermal energy?	Example of study session handouts
3- 3	Question items for questionnaire	Preparation of questionnaire	Are the questions designed to elicit honest opinions?	Questionnaire template
3- 4	Successful and unsuccessful examples of advanced regions	Sorting out benefits and risks	Are the contents not causing unnecessary anxiety?	Example of study session handouts
3- 5	Utilization of government's expert dispatch system	Understanding and rearrangement of dispatch system	Have appropriate experts been selected?	National dispatch system
3- 6	Analysis of questionnaire results	Aggregation of questionnaire results	Is the interpretation fair?	Survey results
3- 7	Preparation of draft request form	Creation of request form	Are the contents beneficial to the local area?	Template for request letter
3- 8	Aggregation of individual requests	Organizing results of hot spring monitoring	Is accurate information being conveyed appropriately?	Example of opinion summary
3- 9	Creation of benefits through current utilization	Aggregation of opinions and request organization	Is accurate information properly summarized?	Example of benefit presentation
3- 10	Preparation of consent form template	Preparation of consent form	Is there an effort to promote understanding of geothermal nergy?	Template for consent form
3- 11	Acquisition of consent form	Individual acquisition of consent form	Are there any cases of information not being obtained?	Example of consent form acquisition
	4. Steering committee			
4- 1	Reviewed legal agreement draft	Draft creation and legal check	Is the content understood?	Examples of agreements
4- 2	Utilization of government's expert dispatch program	Understanding and advance arrangements of the dispatch system	Have appropriate experts been selected?	Government dispatch program
4- 3	Preparation for meetings and ceremonies	Compilation of survey results	Is a fair interpretation being made?	Example of agenda for contact meeting
4- 4	Sharing of hot spring monitoring results	Organizing geothermal monitoring results	Is accurate information being effectively conveyed?	Example of monitoring results
4- 5	Preparation of consent form template	Preparation of consent forms	Is promotion of understanding of geothermal energy being pursued?	Example of consent form template
4- 6	Obtaining consent forms	Individual acquisition	Are there any omissions in the acquisition process?	Example of obtaining consent form
	5. Monitoring of Engagement			
5- 1	Agenda for meetings and ceremonies	Agenda creation	Is promotion of understanding of geothermal energy being pursued?	Example of agenda for council meeting
5- 2	Confirmation of next meeting's agenda	Management and secretariat	Is fair operation being ensured?	Example of minutes for council meeting
Common	Meeting minutes	Compilation of records	Are there any omissions in the description of important matters?	Example of meeting notes
Common	Daily information sharing within the team	Reporting, communication, discussion, meetings	Is an agile approach being taken?	Emails, etc.

In the consideration based on practice, specialized technology required for geothermal development as well as the team that considers regional development measures and members that consider snow-melting methods are required to respond to the needs of hot spring users and local governments. To respond, forming a wide and diverse team with different specialties was necessary, and we focused on teamwork to avoid personal responses.

7.2. Having a Clear Vision

The Agile method is characterized by having a clear vision and a sense of purpose. When formulating strategies, the civil engineering consultant must engage in diverse activities that align with the needs of stakeholders to create new values without being constrained by existing perspectives. These activities are integral to consensus-building.

7.3. Flexible Response and PDCA Cycle

Unlike the waterfall method, the number of hot water resources that can be obtained and quick corrections to meet the needs of hot spring users have led to feedback as a measure against road snow melting for open-air baths and consideration for the business of edible flowers. Consequently, the multistage utilization method was expanded.

7.4. Effects of Using the Management System

The management system in Table 2 clarifies the roles of geothermal developers (including civil engineering consultants) in each category and the step-by-step action items for each process. Therefore, activities could be planned and executed in a stepwise manner. This system formalizes the tacit knowledge that we have experienced both in Japan and overseas, and has been constructed as a general-purpose management system for private companies. For each item in Table 2, several actual examples have been prepared based on our efforts, and by creating these general contents, a general-purpose style collection can be prepared. Furthermore, the content is expected to evolve as cases accumulate. By using such a system, situations wherein the business is interrupted or abandoned owing to the emergence of risks can be avoided. Furthermore, it is necessary for offering explanations and decision making to local stakeholders and the parent organization of the project organization.

7.5. Challenges and Summary of the Agile Method

In traditional civil engineering consultations, the waterfall approach, in which the client formulates specifications and the consultant performs the work accordingly, is predominant. However, in projects such as consensus-building activities in geothermal development, where goals are constantly changing, we believe that activities carried out by teams adopting the agile method can better leverage the diversity inherent in consultants.

Human resources in engineering, sales and administrative management, which conventional civil engineering consulting firms have supposed to be key personnel, would not be sufficient, if geothermal developer try to play a role of such developer as defined in this paper, and the human resources would need to cover the area of finance, accounting and tax, law, and regional economic development. It is also needed that engineers, for example, extend their knowledge widely into the area of finance, law and so on, through practical work and self-study.

In addition, experts from local universities are supposed to participate in the Geothermal Community College, making a good relationship where any opinions in the region could easily be gathered from a neutral standpoint from a third-party perspective, depending on the progress of the project.

However, if the consultants are not accustomed to the agile method, management would be difficult. Nonetheless, each team member often has decision-making authority; hence, a leader with authority cannot manage. Furthermore, each team member can act on their own responsibility; however, if the leader does not manage this properly, the team may move in the wrong direction: the required tasks may become more complex, and appropriate management may be required while using management tools. Therefore, a systematic management system that does not depend on individual skills must be developed.

The agile method is driven by the aim of improving a product, which entails the ability to make improvements and additions. Consequently, achieving the final goal becomes challenging, even with a well-planned strategy. Therefore, focus should be placed on constantly creating better outcomes, embracing changes, and making adjustments.

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