Geothermal Power Development in New Zealand
- Lessons for Japan -

Research Report

Emi Mizuno, Ph.D.
Senior Researcher
Japan Renewable Energy Foundation

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2-18-3 Higashi-shimbashi Minato-ku, Tokyo, Japan, 105-0021
Phone: +81-3-6895-1020, FAX: +81-3-6895-1021
http://jref.or.jp

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Executive Summary

The purpose of this paper is to examine how New Zealand has overcome some of its barriers to geothermal power development and investigate ways which Japan can emulate the recent geothermal development success in New Zealand. New Zealand was selected as a case because of its similar institutional and technical levels, as both Japan and New Zealand are well-developed OECD countries that have economic and democratic political systems. Further, New Zealand has experienced environmental problems caused by geothermal development in the past and developers have made efforts to collaborate with local Maori people; the situation thus has some similarities from which Japan can learn in terms of building good relationships with local hot spring communities and other stakeholders. Understanding how New Zealand has overcome some of these difficulties can benefit Japanese policymakers and developers. In particular, the paper focuses on the following issues: 1) the institutional and policy framework for geothermal development; 2) cooperative relationship building with the Maori community; 3) policy and business-side efforts to reduce the long lead-times of geothermal projects; and 4) the cost competitiveness of geothermal projects.

New Zealand is located in a volcanic region and is blessed with geothermal resources; as such, it started geothermal power generation early. However, unsustainable geothermal extraction practices in the past have caused various environmental problems such as land subsidence and the disappearance of geysers. To overcome these problems, New Zealand has developed a unique institutional framework for natural resource management. Such institutional framework formation and adjustment efforts over the years have reduced the uncertainties related to the development permit process and created a business-friendly environment.

- A single law called the Resource Management Act (RMA) of 1991 governs geothermal (and other natural resource) development and delegates clear responsibilities to the Ministry for the Environment, the Environmental Court, Regional and District Councils and developers.
- Under this law, each Regional Council has to create Regional Policy Statements (RPSs) and Regional Plans, which classify developable and undevelopable geothermal resources and balance resource development and environmental protection. Councils also have the responsibility to process development permit applications called Resource Consent and decide on each application.
- The Strategic Environmental Assessment (SEA) process is required for RPSs and Regional Plans, ensuring consensus on resource management at the regional level.
- The 2009 amendment of the RMA added an alternative Resource Consent application path for large-scale projects of national significance in order to shorten application processing times.
- Assessment of Environmental Effects (AEE, equivalent to Environmental Impact Assessment) must be carried out and submitted to a Regional Council as part of the Resource Consent application. RPSs and Regional Plans stipulate the information necessary for the application and methods of assessment. While implementation flexibility by the Regional Council reduces unnecessary burdens on developers, the requirement of the periodic monitoring and reporting of project performance regarding environmental management after commencement forces developers to manage projects in a responsible manner. Gaining development rights creates responsibility for the developer to the Regional Council, local community and the environment.
- Staged development, the reinjection of fluids and the implementation of geothermal system management plans contribute to sustainable geothermal resource management.

Another unique aspect of geothermal development in New Zealand is the collaboration with local Maori people. A large proportion of developable geothermal resources in New Zealand are under the lands owned by a number of Maori people, and developers need to obtain access rights to these lands from those multiple landowners. Historical conflicts between Maori and European immigrants as well as environmental problems on Maori properties caused by previous geothermal development make gaining

trust from Maori difficult for developers but essential. Various business efforts have been made over the years.

- Forming Joint Ventures with Maori Trusts has been a successful method, as arrangements are made to provide continuous and tangible rewards such as constant royalty payments, carbon credit sales, new employment opportunities as well as the attainment of business knowledge and capacity through commercial deal making and business activities. The transformation of different Joint Venture ownership arrangements over the years also shows the increasing trust between developers and Maori people.
- Such ventures benefit developers, as local residents support them to navigate various institutional and business processes smoothly and reduce Resource Consent processing time.
- Developers have also made continuous efforts to share technical information and provide both formal and personalized mutual understanding opportunities to local communities by bringing third-party experts for environmental and business evaluation and utilizing different media to explain projects to local people.

As for lead-times, the complete lead-time for geothermal power development from resource survey to plant commission can be five to seven years in New Zealand. This is not considered to be a strong bottleneck in New Zealand, as it is not particularly longer than any other renewable energy projects. There are both institutional and business sides of efforts to reduce lead-times.

- In terms of institutional mechanisms, the statutory application processing time limits defined by the RMA 1991 are an important measure to reduce processing time and uncertainty. Additionally, a new national Resource Consent process created for projects of national significance in 2009 shortens application processing to nine months from the usual one year to two years and reduces costs and uncertainties tremendously.
- As for business-side efforts, developers aim to reduce lead-times by simultaneously advancing Resource Consent applications and various other business contract negotiations as well as engaging in fast-track construction practices by coordinating different construction actors and logistics.

The cost competitiveness of geothermal is also very strong in New Zealand. The target to meet 90% of electricity generation from renewables by 2025 also pushes the trend for renewables.

- Domestic cost comparison studies show that geothermal power is most competitive among several fossil fuels and renewable energy options on per unit of generated electricity basis. The high load factor and zero fuel costs can make the geothermal total cost per unit of electricity generated the lowest cost power generation option without financial incentives such as feed-in tariffs, even though capital costs per KW are expensive.

Based on the findings from the analysis, the New Zealand institutional system, which provides a clear framework by centering on Regional Councils in the development permit process, is very different from the complex institutional system in Japan, which adds project risks by lengthening the development permit process. The difference is also obvious in AEE practices: Regional Councils in New Zealand perform AEE in a flexible manner by corresponding to the characteristics of each geothermal field and the actual and potential impacts on the local community. This can be carried out because policy direction is clearly set with very few uncertainties in the RPSs, which are adopted with consensus after SEA. This also helps reduce the uncertainties of project AEE procedures for developers and other stakeholders. A strong stance for encouraging staged development benefits the sustainable resource management of geothermal resources, too. In addition, sincere attitudes and efforts by developers to build collaborative relationships with local residents in New Zealand provide useful examples and lessons for Japanese developers to create good relationships with local hot spring communities in Japan.

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1. Introduction

The Fukushima nuclear plant accident caused by the massive earthquake and tsunami on March 11, 2011 created strong and renewed public interest in renewable energy in Japan. The past two years have seen the passage and implementation of the new Renewable Energy Promotion Act, which has introduced the feed-in tariff system to Japan and encouraged many to search for new business opportunities. At the same time, there are still numerous problems with the orderly deployment of renewable energy projects, including various layers of regulations, which can hinder the development permit process. There are also issues specific to certain renewable energy technologies and sources.

Among the many renewable sources, geothermal is considered to have advantages due to the abundant resources found in Japan as well as its base-load characteristics, which are different from other intermittent renewable sources such as solar and wind. However, new large-scale geothermal projects have not been built in Japan for more than a decade due to numerous barriers, some of which are Japanese-specific and considered to persist even under the new feed-in tariff regime. Without removing such barriers, geothermal power development in Japan will remain a costly option.

The purpose of this paper is to examine how New Zealand has overcome some of its barriers to geothermal power development and investigate the ways in which Japan can emulate the recent geothermal development success in New Zealand. New Zealand was selected as the case because of its similar institutional and technical levels to Japan, while both nations are also well-developed OECD countries that have suitable economic and democratic political systems. Further, New Zealand has experienced environmental problems caused by geothermal development in the past and developers have had to collaborate with local Maori people. Japan can learn from this in terms of building good relationships with local hot spring communities and other stakeholders. Understanding how New Zealand has overcome some of these difficulties can benefit Japanese policymakers and developers. In particular, the paper focuses on the following issues: 1) the institutional and policy framework for geothermal development; 2) cooperative relationship building with the Maori community; 3) policy and business-side efforts to reduce the long lead-times of geothermal projects; and 4) the cost competitiveness of geothermal projects.

The paper is composed as follows. Following this introduction, the second section briefly explains the general situation of geothermal development in New Zealand. The third section examines the policy and institutional framework that governs geothermal development in New Zealand. The fourth section analyzes the environmental problems caused by geothermal development in New Zealand in the past and the current remedies. The fifth section introduces examples of the cooperative relationships built between geothermal developers and local Maori communities. Then, the sixth section explores policy and business-side efforts to reduce the lead-time of geothermal development. The seventh section examines the cost of geothermal power generation in New Zealand and compares it with other power generation options in the country. The last section concludes the paper by summarizing the lessons from New Zealand.

2. Geothermal Resources and Geothermal Power Development in New Zealand

1) Geothermal Resources in New Zealand

New Zealand has high tectonic activities and good geothermal resources. Geothermal energy contributes approximately 11% of its total primary energy supply and 13% of the electricity supply of the country (EECA, 2012; NZGA, 2012b).

Figure 2-1 shows the locations of major geothermal areas. In terms of geothermal resources with temperatures above 200°C suitable for power generation, they are concentrated in North Island, especially in the Taupo Volcanic Zone (Waikato region), which is shown in orange in Figure 2-1, and the Ngawha geothermal field, which is located northwest of the Taupo zone. In the Taupo Volcanic Zone, half of the 29 identified geothermal areas are considered to be suitable for resource utilization and about 750 MW of geothermal power generation capacity are installed in this field. Another 25 MW are installed at Ngawha. The low temperature zones scattered across the country are mainly used for recreational purposes (NZGA, 2012a; 2012b).

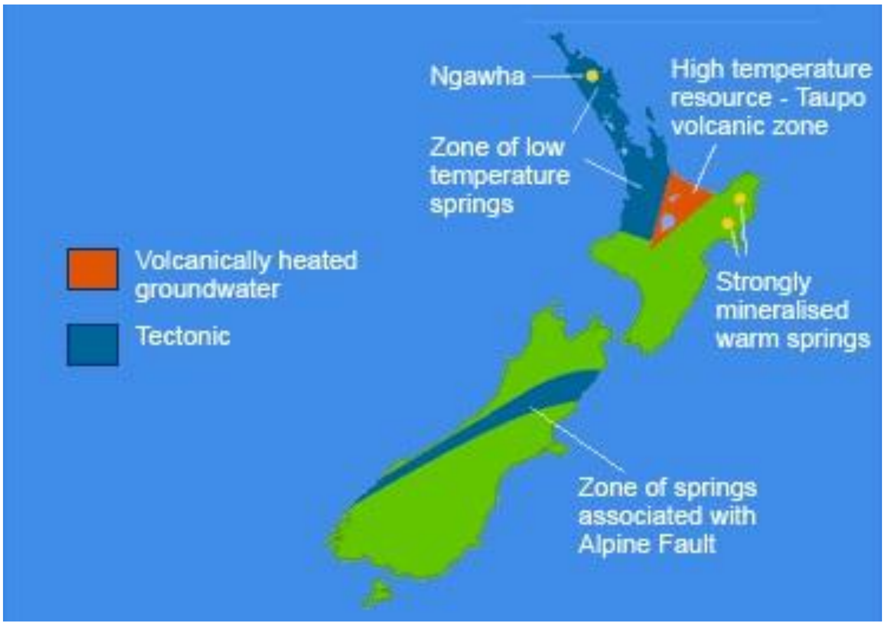

Figure 2-1: Major Geothermal Areas in New Zealand
Source: Image courtesy of EECA (2012)

Figure 2-2 shows the locations of the 14 national parks in the country. Comparing Figures 2-1 and 2-2 demonstrates that the two most prominent areas for geothermal power development are outside national park areas, which indicates the ease of development compared with Japan. Figure 2-3 shows the locations of the geothermal resources in the Taupo Volcanic Zone.

Table 2-1 classifies the three types of geothermal resources suitable for power generation in New Zealand. Even low temperature resources in this table have an average temperature of 230°C, indicating that the country has rich, productive and blessed geothermal resources for power generation.[1]

[1] In Japan, high temperature geothermal resources suitable for power generation are considered to be those that have temperatures above 150°C in general.

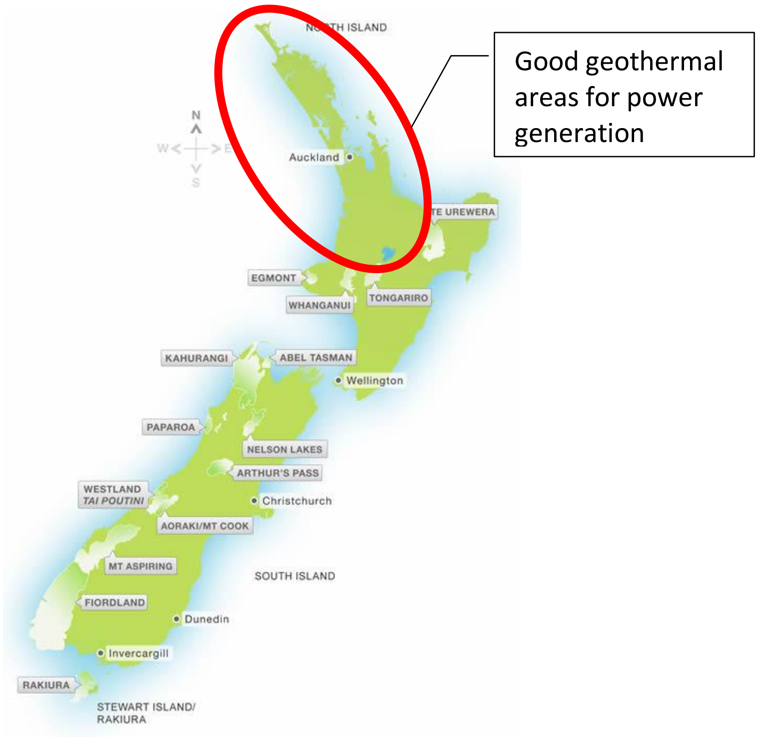

Figure 2-2: Map of National Parks in New Zealand
Source: Image Courtesy of the Department of Conservation/Explore New Zealand 2012

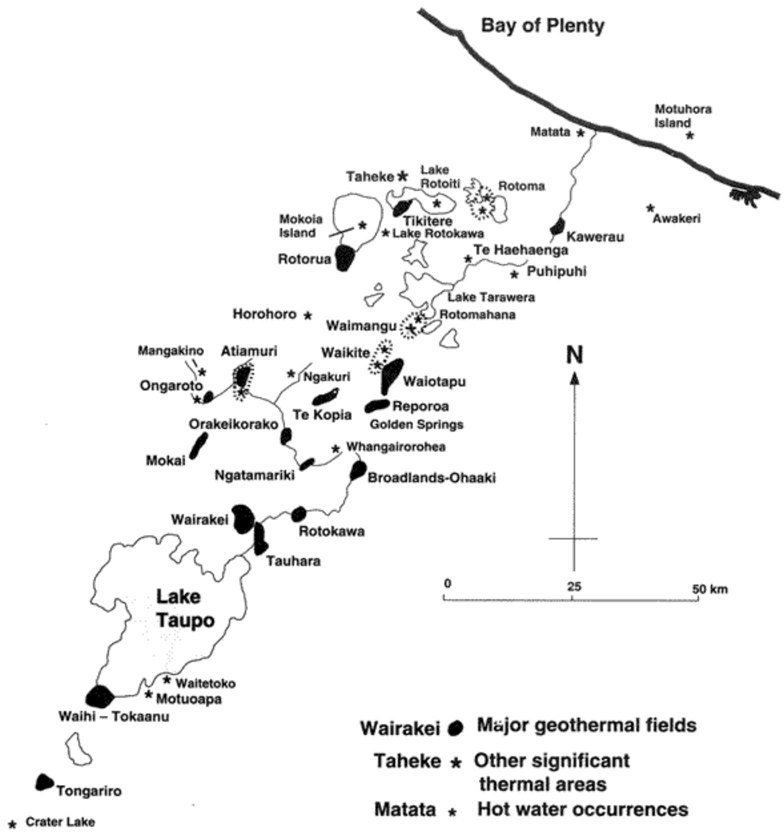

Figure 2-3: Map of the Taupo Volcanic Zone Geothermal Field
Source: Image Courtesy of NZGA (2012a)

Table 2-1: Three Resource Types in New Zealand
Source: SKM (2009)

Resource Type	Resource Temperature	Excess Enthalpy	Wellhead Delivery Pressure	Example Fields
High temperature / Highly productive	>300℃	10% above the enthalpy of water 300℃	20 bara	Mokai, Rotokawa, Kawarau
Medium temperature/ Moderately productive	Average 260℃	Liquid reservoir with no excess enthalpy	5 bara	Wairaikai, Ohaaki, Tauhara
Low temperature/ Moderately productive	Average 230℃	Liquid reservoir with no excess enthalpy	5 bara	Ngawha, outflow zone of high temperature zone

2) Geothermal Power Generation in New Zealand

Electricity Sector of New Zealand

In New Zealand, power generation is open for competition, as the Electricity Industry Reform Act 1998 unbundled power generation and transmission sectors. The latter is owned and controlled by the Crown (Trans Power).

Up to the mid-1980s, both the generation and the transmission of electricity was the responsibility of the Crown; 100% of electricity generation capacity and transmission was owned by the Electricity Division of the Ministry of Energy, and distribution to the majority of consumers was carried out by 61 Electricity Supply Associations, while a small number of larger consumers were served by the Electricity Division of the Ministry of Energy through its transmission lines. This situation changed following the two National Acts in 1986. The Commerce Act of 1986 provided a framework for limiting monopolization and encouraging the development of competitive markets. The State-Owned Enterprises (SOEs) Act of 1986 started a process of the commercialization of the government's trading activities; the Electricity Corporation of New Zealand (ECNZ) was set up as an SOE electricity generator in 1988 and Trans Power was established as a subsidiary of the ECNZ, ensuring the monopoly status of transmission. Then, the Energy Companies Act of 1992 led to the privatization of some supply associations and began permitting the entry of foreign capital into the energy sector. The Electricity Act of 1992 removed statutory monopolies.

Finally, as a result of the Electricity Industry Reform Act 1998, the ECNZ was split into several competing SOEs in April 1999: Genesis Power Ltd. (18% of total generation capacity); Mighty River Power Ltd. (13%); and Meridian Energy Ltd. (30%). The fourth SOE was Contact Energy Ltd., with 25% of total generation capacity, which was floated on the stock market in mid-1999. These four companies currently dominate the New Zealand electricity generation market. Among them, Mighty River Power and Contact Energy are very active in geothermal power development.

Geothermal Development

The first geothermal power plant was commissioned in 1958 in New Zealand. Thereafter, the installed capacity stayed at more or less 280 MW until the mid-1990s. However, development has flourished in recent years. By the end of 2010, 747 MW of geothermal power generation capacity had been installed, and a series of further developments are planned. The two important drivers of this recent increase in geothermal power generation capacity are 1) alleviating the power supply shortage stemming from restricted hydropower generation due to dry weather and 2) achieving independence from imported oils, LNG and coals (NZGA 2012b). New Zealand was ranked sixth in geothermal power generation capacity in the world in 2010 (IGA, 2012), while renewables contributed more than 70% of electricity generation. The renewable target of the New Zealand government is 90% by 2025 (Ministry of Economic Development, 2011b).

Lawless (2002) estimated the high temperature geothermal resources that can be accessed by existing technologies in New Zealand. His estimates showed a median value of 3600 MW of power generation, which is approximately 4.8 times the current installed capacity, indicating that only 20% of the potential resources are currently utilized.

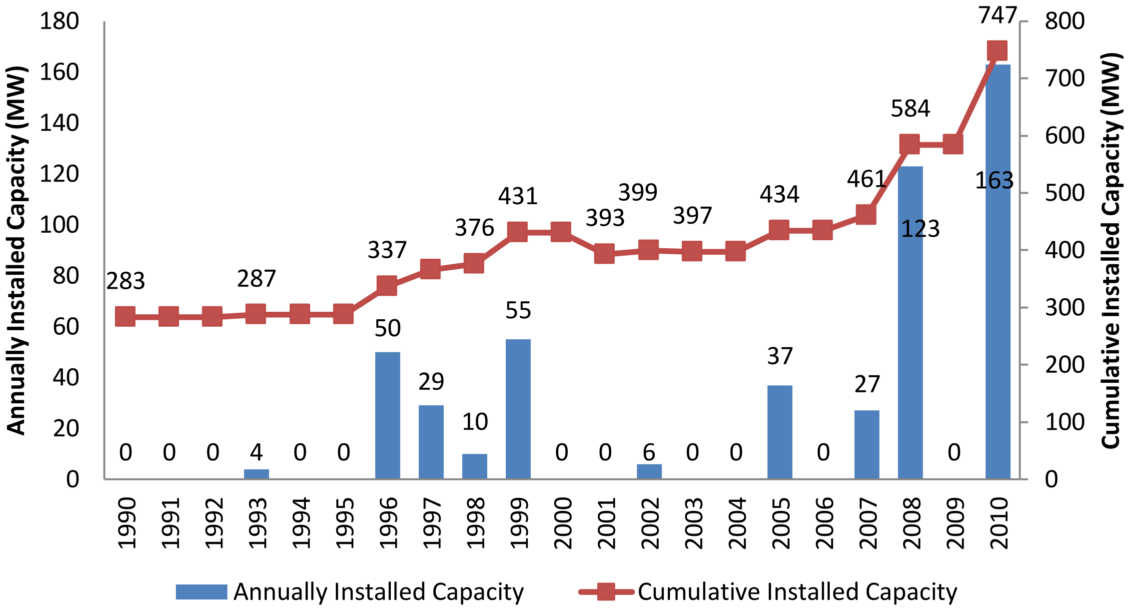

Figure 2-4: Installed Geothermal Power Generation Capacity in New Zealand
Data Source: NZGA (2012b)

3) Section Summary

New Zealand has rich geothermal resources suitable for power generation and a long history of geothermal power development. The country's geothermal installed capacity is ranked sixth in the world and it provides 13% of its electricity supply. The resources are considered to be high quality and high enthalpy. Many of the resources and most prominent areas for geothermal power projects are located in North Island, in particular in the Taupo Volcanic Field and the Ngawha geothermal field, and they are not parts of any national parks.

3. Policy and Institutional Framework for Geothermal Development in New Zealand

1) National Framework for Geothermal Power Development

In New Zealand, while the Crown Minerals Act 1991 covers the management of oil, gas and mineral resources, geothermal resources are considered to be water. Therefore, they are not owned by the Crown and are instead controlled by the environmental management legislation called the Resource Management Act (RMA) 1991. The difference between these two laws is that the resources governed by the Crown Minerals Act 1991 are owned by the Crown and can be developed through land leases, while geothermal resources are not (EPA, 2012a; NZGA 2011; White 2006).

The purpose of the RMA is to "promote the sustainable management of natural and physical resources" (New Zealand Government, 1991). The Act defines the sustainable management of resources as follows:

> "managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural well-being and for their health and safety while meeting the needs of future generations, safeguarding the environment and avoiding, remedying or mitigating any adverse effects of activities on the environment" (New Zealand Government, 1991).

The RMA has been updated and amended several times since 1991. It is responsible for the sustainable management of natural and physical resources in New Zealand. The RMA delegates different responsibilities among the Crown and Regional and District Councils. While the Crown is responsible for resource issues of national significance and developing National Policy Statements (NPSs) and National Environmental Standards (NESs), Regional Councils develop Regional Policy Statements (RPSs) and Regional Plans and take care of the issues concerning soils, air, water, pollution and coasts, while District Councils deal with land subdivisions and noise by setting and implementing RPSs and Regional Plans.

As for geothermal development, Regional and District Councils must follow the guidance set by the NPS on Electricity Transmission (2008) and the NPS on Renewable Electricty Generation (2011), and change their RPSs and Plans if necessary within four years of the approval of the respective NPS. However, this does not mean that NPSs are a substitute for or prevail over the statutory purpose of the RMA. Rather, NPSs are "intended to be a relevant consideration to be weighed along with other considerations in achieving the sustainable management purpose of the Act" (MfE, 2012a).

The RMA requires:

- Each Regional Council to develop an RPS (policy) and a Regional Plan (the rules to implement the policy), both of which require Strategic Environmental Assessment (SEA) to be performed (Section 32 of the RMA).
- A developer to obtain Resource Consent (authorization) from a relevant Regional Council to proceed with certain development activities or uses of natural/physical resources. Resource Consent does not assign the holder the ownership of the resources, but rather the right to use them under the stated conditions. Resource Consent provides the holder with a maximum 35 years of resource utilization right. The holder must exercise the right within five years of the date of Consent approval.
- Regional Councils to issue and administer Resource Consent that concerns the effects of the use of natural resources, including geothermal power generation development, while each application for Resource Consent must include an Assessment of Environmental Effects (AEE).

Figure 3-1 illustrates the planning framework for geothermal power development under the RMA and the 2009 Amendment of the RMA in New Zealand.

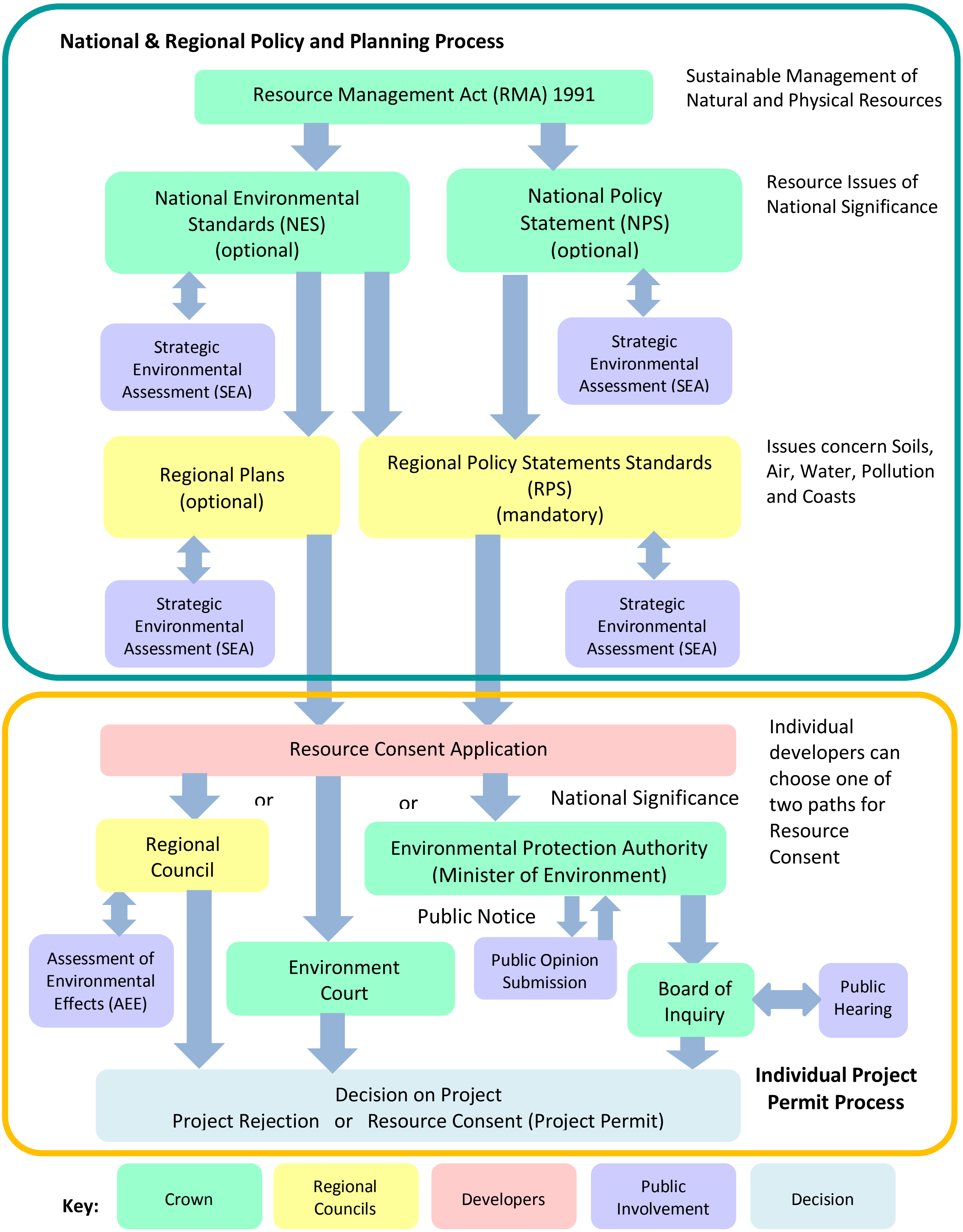

Figure 3-1: RMA Framework for Geothermal Resource Management

The significant aspect of the framework shown in Figure 3-1 is that the RMA requires all NESs, NPSs, Regional Plans and RPSs to undergo the SEA evaluation process (Memon, 2005). SEA is defined as "a systematic process for evaluating the environmental consequences of proposed policy, plan or programme initiatives in order to ensure they are fully included and appropriately addressed at the earliest appropriate stage of decision-making on par with economic and social considerations" (Sadler and Verheem, 1996). By implementing environmental impact assessment (EIA) on policies, plans or programs, SEA can form local consensus regarding resource management and development before each individual project starts, which reduces the level of uncertainty of project approval by a relevant authority.

Because the development of RPSs and Regional Plans, the evaluation of project-based AAEs, and Resource Consent and permit processing are usually performed by Regional and District Councils, environmental policy and planning are relatively integrated and centralized at regional and district levels. Each geothermal power station is required to obtain a set of about 15 Resource Consents, which cover activities such as geothermal fluid and freshwater extraction, steam and other gaseous discharge to air, the reinjection of geothermal fluid into the ground or its discharge to land or water, geothermal well drilling and road construction and management.

Although the above is still the basis for the conventional Resource Consent path for geothermal resources, the New Zealand Parliament passed the Resource Management (Simplifying and Streamlining) Amendment Act 2009 (RMAA 2009) in September 2009, and added a new process for Resource Consent. As a result, three paths for the Resource Consent process are now available for developers, who can lodge their applications 1) to a relevant Regional Council for a hearing by a Board established by the Council (conventional); 2) directly to the Environment Court with the relevant Regional Council consent; or 3) directly to the Environmental Protection Authority (EPA), where the Minister for the Environment decides to 'call in' and a Board of Inquiry makes a decision. Although applicants can choose which process to be taken for their application, the second option is only for cases where developers consider that appealing to the Regional Council decision to the Environment Court is inevitable, and the third option is reserved only for large-scale projects with national significance. For the third option, individual developers can lobby for their projects to be 'called in' in order to shorten the approval process (Brockelsby, 2012a, 2012b). In either path, however, the same RPSs and Plans are still the basis for the decision, and public consultations are mandatory.

2) Regional Framework and Process

Only three Regional Councils (the Northland Regional Council, the Waikato Regional Council and the Bay of Plenty Regional Council) have the areas of high temperature geothermal systems and responsibility to issue Resource Consent for geothermal development. The Waikato Regional Council and the Bay of Plenty Regional Council have a Memorandum of Understanding to manage the geothermal resources of the Taupo Volcanic Zone in an integrated way, including sharing data and resources and aligning policies. Among them, the Waikato Regional Council (Environmental Waikato) administers approximately 80% of the high temperature geothermal resources in the country, while the Northland Regional Council only administers the Ngawha geothermal system, the only known high temperature geothermal system in New Zealand outside the Taupo Volcanic Zone (NZGA, 2011; 2012b).

As mentioned above, Regional Councils have huge responsibilities; they must clarify the important issues related to resource management, set clear policy objectives, define methods to implement them, expect results, and monitor the results to make sure sustainable management is carried out. In addition, they have responsibilities to choose the most effective and fairest policy and implementation methods to ascertain the results.

The Waikato Council and Bay of Plenty Council, both of which administer multiple geothermal resources, classify geothermal systems into several categories, to which different management approaches need to be applied. Table 3-1 shows the classification by the Waikato Regional Council. Waikato's classification is based on the ranking of each system's characteristics and aims to balance development with the protection of highly valued surface features (NZGA, 2011). Policy objectives are defined for each category of resources, and the objectives and implementation methods are set by the RPS and Regional Plan (Waikato Regional Council, 2000, 2008).

Table 3-1: Classification of Geothermal Systems by the Waikato Regional Council
Sources: NZGA (2011); Waikato Regional Council (2008)

Classification	Characteristics	Geothermal system
Development	Large-scale developments are allowed, only in a sustainable and environmentally responsible manner	Horohoro, Mangakino, Ngatamariki, Mokai, Ohaaki, Rotokawa, Wairakei-Tauhara
Limited Development	Only usages without damaging surface features are allowed	Atiamuri, Tokaanu-Waihi-Hipaua
Research	Only small usages and for scientific research into the system are allowed	Reporoa
	Temporary status for new systems that might be found or created by Engineered Geothermal Systems before reclassification	
Protected	Vulnerable geothermal features valued for their cultural and scientific characteristics. No geothermal water source extraction and damage to surface features by unsuitable land uses	Orakeikorako, Horomatangi, Taupo, Waikite-Waiotapu-Waimangu,Tongariro, Te Kopia
Small	Isolated springs or sets of springs. Not suitable for electricity generation	Numerous low temperature systems

Geothermal development may occur in or near conservation areas such as national parks. In such cases, development has to respect the protections implied in the provisions of the NPS, RPS and Regional Plan. In addition, it may need to include further protections by taking account of the wills of potential objectors to the development and their standing with respect to the project, e.g. whether they are a landowner or a representative of the original local inhabitants (White, 2011).

The most important advantage of such a regional approach is that the policy framework can reflect the views of people and businesses in the region. In particular, it is important for the Waikato region, which has approximately 80% of the country's geothermal resources, to have high stakes in the policies and rules of geothermal development. However, such a regional approach can prevent a wider national view from being reflected in the plan. In addition, having diverse management approaches to geothermal and other natural resources is not logical from national perspectives. From the perspectives of developers, working to different rules in different regions can increase compliance time and costs and reduce business efficiency (Brockelsby, 2012a).

Time required for Resource Consent

As for geothermal development, along with the clarity of responsibility and the procedure of development permit applications, time requirement for the Resource Consent process is another important issue. Significantly, the RMA does set statutory times for various stages of the consenting process at a regional level. For geothermal power plant projects, the application is usually notified to the public. In such cases, each process has to follow the statutory times indicated in Figure 3-2.[2]

[2] If the project is not going to be notified to the public, the decision for whether to grant Resource Consent has to be made within 20 days of the receipt of the application.

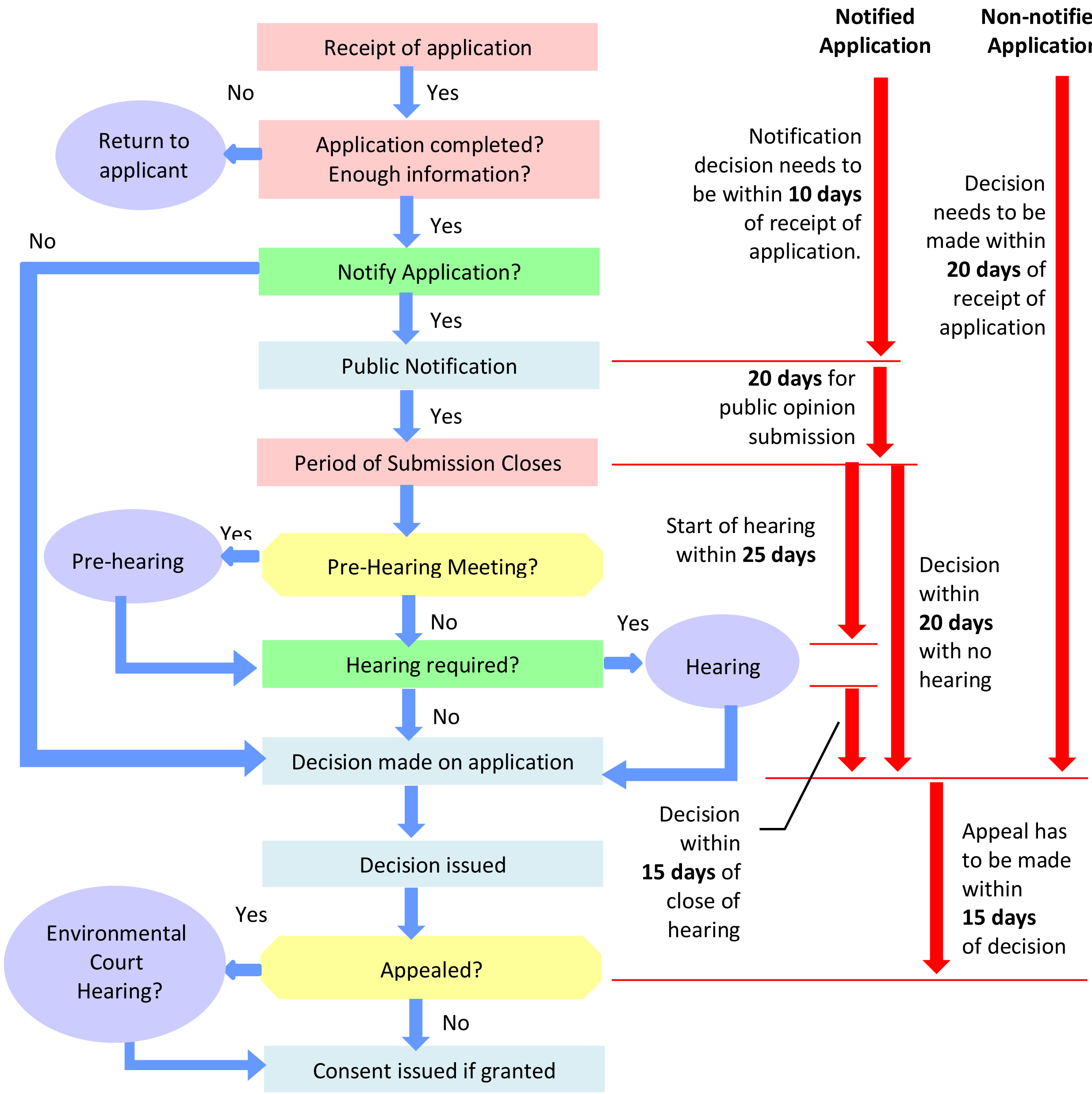

Figure 3-2: Statutory Timeframe of the Resource Consent Process under the RMA
Sources: MfE (1998); Waikato Regional Council (2012a)

The usual time required to obtain Resource Consent varies significantly from 18 months to five years due to many factors. The Consent processing time for recent large geothermal projects has been between six and 12 months in the Waikato Regional Council (Brockelsby, 2012a). In recent years, despite the clear statutory timeframe set by the RMA, time delays have become a problem for all kinds of developments. The compliance rates of the statutory time vary among Regional Councils. For the three Regional Councils with high temperature geothermal systems, the 2005/2006 MfE survey shows that the Northland Regional Council has a 98% compliance rate, the Waikato Regional Council an 84% compliance rate and the Bay of Plenty Regional Council a 95% compliance rate (MfE, 2006). This indicates that the three Regional Councils generally have high rates of compliance.

Municipality Capacity for Resource Consent Processing and Decision-Making
As for processing Resource Consent applications, a Resource Consent officer at the Regional Council writes an evaluation report for each publicly noticed application. The report includes those matters the Regional Council must consider when assessing consent applications and submissions. These matters are set out in sections 104 and 107 of the RMA. The report also needs to detail whether the applied activity:

- Conflicts with any policies or plans
- Considers the principles of the Treaty of Waitangi
- Considers and promotes other matters, such as:
    - Efficient use of natural resources
    - Public access to the coastal marine area, lakes and rivers
    - Protection of wildlife habitats
    - Traditional Maori values
    - Heritage sites and areas
    - Maintenance and enhancement of the environment.
- Will have positive or negative effects on the environment
- Has alternatives
- May breach water quality standards.

(Waikato Regional Council, 2012d)

Regional Councils have to have a high capacity to process and decide on Resource Consent applications, and carry out monitoring. The Waikato Regional Council deals with approximately 1200 applications per year of various sizes. As of August 2012, this Council employed roughly 50 staff members to process Consent applications and implement and monitor Consent decisions. These employees of the Resource Consent department are divided into seven teams, each of which is in charge of Infrastructure, Industry, Water Quality, Coast, Farming, Land and Soil. Each team has three to 10 staff member and one manager. As a whole, the department can be broken down into seven managers, 10 senior staff members, 15 mid-level staff members and 15 junior-level staff members. In addition, six administrative staff members (one manager and five staff) support the professional staff members. Most professional staff members have bachelors or higher degrees in earth science, biology, chemistry and other science backgrounds. Those without science backgrounds have professional degrees in planning and resource management. The Regional Council is contemplating increasing staff members that have planning and resource management backgrounds in order to meet expected needs in the future (Brockelsby, 2012c).

3) New National Resource Consent Framework and Process for Proposals of National Significance

A number of cases of reported time delays of Resource Consent issuance at the regional level have caused national debates for streamlining the permit process in New Zealand. In addition, the Crown also saw that local authorities had not been adequately making decisions on large, nationally important infrastructure, as regional and local issues and interests often inappropriately trumped national interests. These concerns were the forces behind the passing of the RMAA 2009, which created a new Resource Consent process for proposals of national significance, as briefly mentioned above (MfE 2012c; Brockelsby, 2012a).

Proposals of National Significance
The RMA 1991 authorizes the Minister for the Environment to intervene in the decision-making process for proposals of “national significance.” These proposals are applications for Resource Consent, notices of requirement and requests for a regional plan or private plan change. As for the definition of national significance, the RMA 1991 does not offer a clear definition. Instead, it provides example factors, including if it:

- Is of widespread public concern;
- Involves the significant use of natural and physical resources;
- Is relevant to New Zealand’s international obligations;
- Will assist the Crown in fulfilling public health, welfare, security or safety obligations or function;

- Is likely to contribute to significant changes to the environment; or
- Relates to network utilities extending in more than one district or region. (MfE, 2012b; EPA 2012c)

Once proposals are lodged with a respective local authority, either the applicant for the proposal or the local authority that would normally make the decision can formally request the Minister to intervene. Alternatively, the Minister can decide to intervene on his/her own.

Two New Processes created by the RMAA 2009

As of October 2009, applicants with proposals of national significance can also apply for Resource Consent directly to the EPA. The EPA was established by the RMAA 2009 under the MfE in order to centralize and streamline the decision-making process of national significance. Once the request for intervention by the Minister is made or the Minister decides to intervene on his/her own, he/she has six options (MfE, 2012b):

- Not to intervene;
- To call in the matter;
- To make a submission on the matter for the Crown;
- To appoint a project coordinator;
- To direct the consent authorities to hold a joint hearing if the matter involves more than one authority; or
- To appoint an additional hearings commissioner to a hearings panel if the local authority decides that commissioners should be used.

Once the Minister decides to call in the matter, it is referred to an independent Board of Inquiry (the members are appointed by the Minister). In such cases, the respective local authority loses the decision-making power on the proposal. The EPA must also give public notice of the Minister's direction and receive submissions on the proposal. All received submissions as well as all relevant materials collected by the local authority must be provided to the Board of Inquiry by the EPA. The decision must be made within nine months of the public notification (EPA, 2012b).

The other important change is that appeal rights are very limited with the Board of Inquiry process in order to reduce the risks of litigation by processing the applications once and properly. This call in process and the EPA were both established by the 2005 Amendment of the RMA. The RMAA 2009 just clarifies the role of the EPA further and establishes a much more prescribed process for dealing with call ins (Brockelsby, 2012b).

The second option created by the RMAA 2009 is "direct referral" to the Environment Court. This option can be applied to any kinds of projects, not only of those of national significance. The Environment Court listens to appeals of decisions made by Regional Councils. When a developer considers that the decision made by the local authority will be appealed, he/she can bring the Resource Consent application to the Environment Court directly, skipping the Regional Council decision-making process in the first place to save time and making a two-step process into one. However, this must have the prior agreement of the relevant Regional Council regarding the application being directly referred to the Environment Court (Brockelsby, 2012b).

Thus, the new EPA process (the Board of Inquiry without appeal to the Environmental Court) and the direct referral process to the Environment Court are a one-stage, while the standard regional process is in two stages (Council decision with appeal to the Environment Court). These new processes can shorten the time taken for the Resource Consent process significantly, weight national interests properly and reduce the resource commitment of the Regional Council. However, some shortcomings should be pointed out. The process is considered to be less user-friendly for the affected public. There is also a possibility that the nine-month decision-making time may not be enough to make quality decisions. In addition, in either case the respective local authority loses the decision-making power on the proposal. While the process limits using the abundant experiences of Regional Councils and the Regional Councils do not control the final decisions, they still need to administer and enforce them (Brockelsby, 2012a).

Local Benefits

The RMA does not specifically refer to the benefits that geothermal power development can bring to local communities, because local benefits have little importance under the law, which is primarily concerned with the sustainable management of natural and physical resources and an overall judgment of whether the development is consistent with that principle. The focus is not the wellbeing or benefits of local communities or people. The principle includes the consideration of the potential effects of the projects and who may be affected directly, while developers are required to demonstrate how they intend to avoid, remedy or mitigate effects to an extent that is appropriate.

However, in practice, because adverse effects on the local environment and/or people cannot be completely avoided, mitigated or remedied, Resource Consent applicants often propose “compensatory” provisions to reduce them. In particular for geothermal projects, although it is common for developers to propose such compensation, it is not in the form of benefits. Regional Councils also make decisions on Resource Consent applications by always taking local benefits as well as regional and national benefits into account. Yet, in recent years, because the Crown considers that Regional Councils place too much emphasis on local benefits and concerns, this became a reason to create the 2009 RMAA and introduce the new fast-track, call in Resource Consent application path to increase the influence of national benefits in decision-making (Brockelsby, 2012b).

Tauhara II Geothermal Power Station

Location: East of Taupo

Commission Date: Resource Consent is granted, the construction project part is currently planned

Contact Energy[3] is planning to build a 250 MW Tauhara II geothermal power station near the city of Taupo. The firm operates the 23 MW Tauhara I geothermal plant (binary) near Taupo, and plans an expansion (Tauhara II). The Resource Consent for Tauhara II has already been granted and plant construction is currently planned, waiting for finance. This project is significant, as it is the first infrastructure project to undergo the new EPA process.

Because Contact Energy considered this project to be nationally significant, as it is a large-scale renewable project, the firm lodged an application for Resource Consent to build and operate the station directly with the EPA on February 19, 2010. The Minister directed the matter to a Board of Inquiry. The public notification of the Minister’s direction was made on April 17, 2010. Following the solicitation of public opinions on the application for Resource Consent, which was closed on May 14, 2010, the Board of Inquiry held a hearing in September and October 2010. Resource Consent was granted in December 2010 and finalized on February 14, 2011.

As for the Resource Consent application, Contact Energy prepared a very thorough proposal including a full set of conditions on consents. It was so comprehensive that the Board of Inquiry largely accepted it (White, 2011). Meanwhile, the Board of Inquiry instructed Contact Energy to engage in facilitated meetings with the public opinion submitters to resolve the issues raised by them during the hearing. These meetings were very successful in terms of resolving the remaining issues and shortening the hearing time, as they motivated everyone to focus on solutions and provided the public opinion submitters the best opportunity to get what they wanted (Brockelsby, 2012a).

Contact Energy considers that the most significant difference with this new process is its short decision-making process, which can usually take two years or so for this kind of large-scale geothermal application.

[3] The firm is the largest geothermal power generator in New Zealand. It is publicly listed.

In addition, another significant difference is knowing that there was no recourse or appeal to the Environmental Court, which reduced business risks tremendously (Stephenson, 2012).

4) Section Summary

In New Zealand, the RMA 1991 clearly delegates the most significant decision-making power to regional/local authorities and provides a clear framework for geothermal and other resource developments as well as a clear development permit procedure. Such a policy framework and processes were not created overnight in New Zealand, but rather they were developed by taking various long-term issues into account.

The RPSs and Regional Plans mandated by the RMA 1991 establish where can be developed by classifying the resource fields in each region. Moreover, the SEA process required for this master policymaking can clear many environmentally related issues and address local community concerns before an individual AEE process begins, reducing development uncertainty and costs and risks for developers tremendously, as they eliminate unlikely development locations in the first place. Therefore, individual projects do not need to prove overall development suitability, as it has already been proven by RPSs and Regional Plans. This means that an individual AEE only needs to prove the effects on the environmental of each project plan and design, which reduces AEE processing time. At the same time, this entire procedure also enables the total regional management of resources and local community consensus to be made before an individual project AEE.

Another important aspect of the RMA is its statutory timeframes, which clearly provide the minimum processing time for Resource Consent for developers. In addition, efforts are made and pressures are imposed to make Regional and District Councils comply with these timeframes.

The new Resource Consent process created by the RMAA 2009 for large-scale projects of national significance greatly reduces the time for the development permit process to nine months from the usual one to two years or more. In addition, the decision made by the new procedure is final, thereby eliminating the risks of litigation. By considering large renewable energy projects to be nationally significant in the future, this new process will benefit many future geothermal projects and developers by reducing project lead-times, costs and various related risks, while taking environmental concerns into account.

4. Environmental Problems and Policy Approaches

New Zealand did not develop this systematic approach to geothermal development overnight. The country has experienced detrimental environmental problems caused by unregulated and unsustainable geothermal resource extraction practices in the past, when the impacts of geothermal development were not well recognized, as none of the knowledge and experiences of such impacts and sustainable geothermal development practices were available. These problems brought about important changes to regulations and policy approaches as well as geothermal resource development and management practices to address environmental issues.

1) Historical Environmental Issues in the Taupo Volcanic Zone

The most damaging environmental effects have been land subsidence caused by the rapid extraction of heat and fluid, which reduces reservoir pressure. For example, the Ohaaki geothermal power station, commissioned in 1989, has been causing the sinking of a nearby marae (communal and sacred place for Maori people), exposing it to flood risks from the Waikato River. In addition to land subsidence, rapid geothermal heat and fluid extraction and overlying land use have caused the disappearance of many geysers and sinter-depositing springs, as water pressure does not recover quickly enough to fuel them. As a result, the ecosystem associated with these geysers and springs have also disappeared.

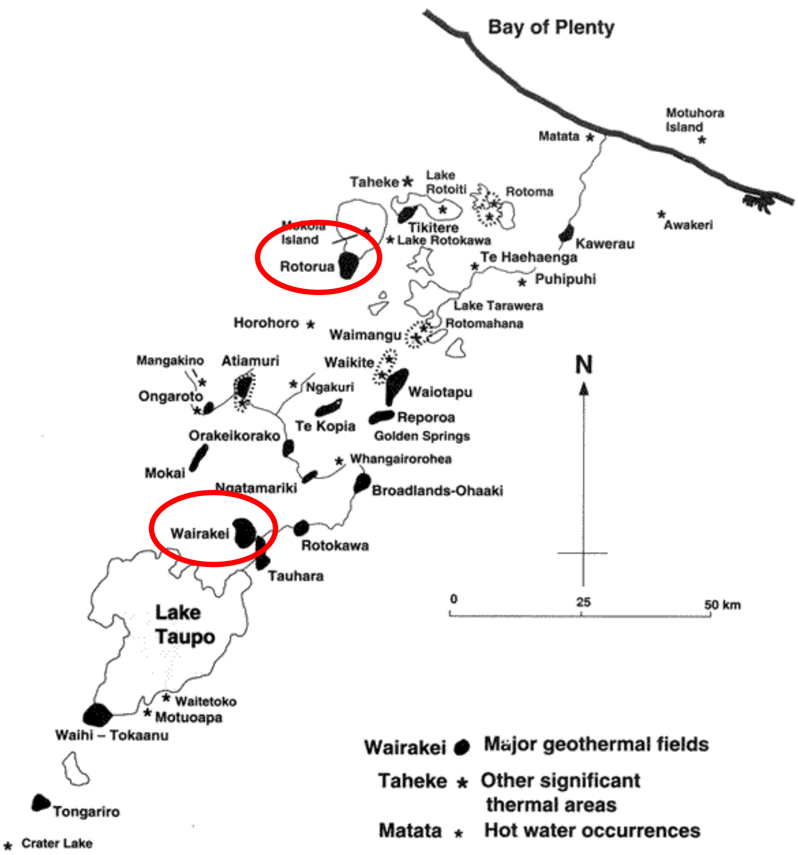

Figure 4-1: Locations of Wairakei and Rotorua in the Taupo Volcanic Zone Geothermal Field
Source: drawn by the author from NZGA (2012a)

These problems have been most visible in the Taupo geothermal field in the Waikato region and with the early Wairakei geothermal power station development. The Wairakei problems started in the 1950s. Water table and pressure changes caused land subsidence, a reduction in the flow of chloride springs and shallow hydrothermal eruptions. These changes also caused a reduction in steam production, and now the extraction capacity levels for some power stations are capped and water/steam reinjection is practiced. Sinking of land also occurred and the highest level of recorded subsidence reached 10 m (NZGA, 2012a; Waikato Regional Council, 2011).

In the Rotorua geothermal field, the decades of unregulated development up to the mid-1980s caused the extinction of major geysers and drying up of hot springs. Considering the effects on tourism, the Crown instituted a program to force geothermal well closures with royalty charges for fluid withdrawal and reinjection credits. These policies reduced the total well discharge by more than two thirds. However, a number of major geothermal features did not recover. With their disappearance, many biological organisms and ecosystem features along with tourism incomes also went (Barrick, 2007; Kelly, 2011).

2) Policy Changes, Current Environmental and Management Issues, and Policy Approaches

The extraction of geothermal fluid and energy that exceeds the natural rate of discharge depletes the usable resources found in upper aquifers. The Wairakei and other geothermal field experiences of the 1950s led to the enactment of the Water and Soil Conservation Act of 1967, which regulated geothermal extraction and discharge by moderating the allocation of geothermal fluid extraction and the rate of extraction. However, the effective policy framework was only in place when the RPSs and Regional Plan under the RMA 1991 were developed in the early 2000s. In the Waikato region, its RPSs and Regional Plan classified the geothermal systems into five categories in order to address the issue of increasingly rare geysers and protect highly valued systems as Protected Systems for conservation. The Regional Plan also reinforced the need for staged development and conservative development approaches as well for monitoring and modeling. Therefore, it created management plans and appropriate mitigation measures of the adverse effects (Brockelsby, 2012a).

Although these issues are not specific only to the Waikato region but common nationwide, the Waikato region has approximately 80% of the country's geothermal resources and its Regional Plan is an important indicator to understand the continuously evolving fronts to address various issues related to geothermal resource management. As the Waikato Regional Policy has major stakes in geothermal development policy in the country, the following introduces its management strategies.

Sustainability Issues – System Classification, Staged Development, Reinjection of Fluid, Monitoring and Reporting, and Single Tapper

The Crown considers geothermal resources to be "public goods" and a renewable energy that the RMA recognizes to be sustained for future generations. The sustainability of geothermal resources is related to the opportunities for energy use by future generations. However, ensuring sustainability is difficult, as it is not defined clearly by law. Moreover, incomplete information regarding the nature, extent and dynamics of geothermal systems, in particular at the beginning of development, and the difficulty acquiring technical capacity to accurately interpret trends in the geothermal system, make sustainable management challenging. This means in practice that the case-by-case determination of sustainability within qualitative (Council) policy framework applications has to be performed (Brockelsby, 2012a).

Regional Council policies recognize "adaptive management" as appropriate for geothermal development. "Adaptive management" is one of the regulatory approaches used in cases where there is limited information about the effects of development. Basically, it 1) defines the policy objective(s) (e.g. sustainable management of the resource and/or minimizing land subsidence and/or avoiding impacts on protected systems/features) within Regional Policy; 2) manages the system in a way to meet that objective(s); 3) monitors to inform the regulator as to whether the objectives are in fact being met; and 4) enables the regulator to require changes to the development approach to better achieve the desired objectives. The Regional Policies and Plans of the Waikato Regional Council follow this sequence (Brockelsby, 2012b; Waikato Regional Council, 2000, 2008).

In order to put this approach into practice, the Waikato Regional Council first classifies all regional geothermal systems into the five categories mentioned in the previous section. This classification is defined in "Policy Three: Classification of Systems" in "3.7.2. Sustainable Management of the Regional Geothermal Resource" in the Waikato RPS and reflects the policy of the Council not to attempt commercial scale development and to protect surface geothermal features in one system simultaneously.

At the individual system level, the efficient use of energy is promoted by 1) the efficient conservation of geothermal energy and fluid; 2) not affecting the stock and flow of geothermal energy and fluid adversely; and 3) not affecting the viability of significant geothermal features either individually or in combination. As long as these conditions are met, the use of energy is permitted in all systems. In particular, for the seven systems in "development" category available for large-scale development (i.e. Horohoro, Mangakino, Mokai, Ngatamariki, Ohaaki, Rotokawa and Wairakei-Tauhara), which have possibilities for non-sustainable outcomes due to energy depletion, the key policy requirements are:

- Staged development (i.e. conservative first stage development and larger development in subsequent stages through utilizing the information collected over time);
- The requirement for a System Development Plan, revised on as-required basis, to show how they intend to manage the geothermal system to sustain the resource and avoid, remedy or mitigate any adverse effects;
- The requirement for a Discharge Strategy (a part of the System Development Plan) to demonstrate how waste fluid will be dealt with and how the effects of discharges will be mitigated or reduced (i.e. whether reinjection occurs infield or outfield, their locations, etc.);
- The requirement for the conceptual and numerical modeling of the reservoir and for using the model to predict reservoir effects over time at the rate of proposed take and reinjection, and the update of the model and prediction as necessary;
- Comprehensive monitoring of the system – trends in pressure, temperature, chemistry as well as land subsidence, seismic activity, geophysical survey, gravity, infrared, hot ground, flora/fauna, springs and other surface features, etc.;
- Reporting and interpreting the information to the Regional Council;
- Appointment by the Council of a Peer Review Panel to assess and evaluate the information (usually a panel of three experts who specialize in geothermal science to provide independent expert advice to the Council. The costs for the Peer Review Panel are paid for by the developer); and
- Resource Consent provisions that enable "adaptive management" (including formal opportunities to review the conditions of consent to enable amendments in response to changing trends over time in order to better ensure the sustainability of the resource)[4]

(Brockelsby, 2012a)

[4] For example, if pressure is falling alarmingly but the developer is not adequately managing that issue, then the Council can, through a formal review of conditions, impose new requirements aimed at addressing it. These consent conditions have considerable inbuilt flexibility in order to enable changes in responses to trends, without undue formality (Brockelsby, 2012a).

Regarding staged development, during the 1990s the Waikato Regional Council had a policy that limited the initial capacity of geothermal power plants below 10% of the resource potential known at the point of the Consent application. However, the concept of adaptive management was introduced later as the Environment Court began supporting the flexible modification of monitoring requirements attached to the Resource Consent. This change gradually increased the initial capacity of the staged development permitted by the Waikato Regional Council through Resource Consent. In short, the Regional Council stopped limiting the initial development capacity of geothermal power plants and changed its approach to reduce the potential environmental effects by adaptive management through monitoring. Through this approach, the role of the third-party review panel became crucial and Resource Consent more dynamic. Further, this approach leaves the responsibility for solving economic issues related to installed capacity to each developer, which makes the Regional Council concentrate only on the sustainable management of resources; the Regional Council thus became able to focus only on deciding whether proposals by developers are sustainable or not under the RMA 1991 (McLeod, 2012).

The Waikato Regional Plan stipulates the rules for takes and discharges, which are specific to each category of geothermal system, thus encouraging the usage of energy- and fluid-efficient technologies and the reinjection of fluid. These rules decide where and what kinds of takes, discharges and reinjections/injections are permitted and set the rates of each activity (Dickie and Luketina, 2005; Waikato Regional Council, 2000, 2007, 2008; Brockelsby, 2012a). In addition, the Ngawha Geothermal Power project outside the Taupo Volcanic Zone proved that the supplementary injection of cold water up to 10,000 tpd was effective to raise reservoir pressures without affecting production temperatures, suggesting the same method can be useful for keeping hot spring temperatures and pressures in Japan (Lawless, 2006).

The significant features of each geothermal system are identified in the Regional Plan, which specifies what kinds of activities are permitted around the features in order to protect them (Waikato Regional Plan, 2008). The Regional Plan also delineates each geothermal field in maps with contours and other geographical features, and each significant geothermal feature is shown clearly on aerial photographs as seen in Figure 4-2 (Waikato Regional Council, 2008).

A potentially difficult resource management issue is probable multiple party operations in one geothermal system (multiple tappers). This is because each multiple tapper that pursues its own business competitiveness makes integrated system management very difficult.[5] Although the Waikato Regional Council has tried to introduce a 'single tapper' policy for each of the seven development systems, the New Zealand Environmental Court has rejected the proposal. Fortunately, the majority of landowners and access rights holders of each system are currently controlled by a single entity, limiting the ability of any other party to mount a viable development proposal and eliminating multi-tapper problems.

[5] The potential shortcomings of multiple tappers include: a non-integrated, piecemeal approach to field development and resource information gathering and monitoring; less than optimal siting of take and reinjection points (due to land access constraints); competition for the resource and a lack of certainty for operators, increasing litigation, regulatory and compliance costs, limiting the ability to plan effectively and encouraging greater than optimal take rates; interference effects between operators; uncertain operator accountabilities as regards adverse effects and their mitigation; and a reluctance to share and/or publicly disclose resource information (Brockelsby, 2012a).

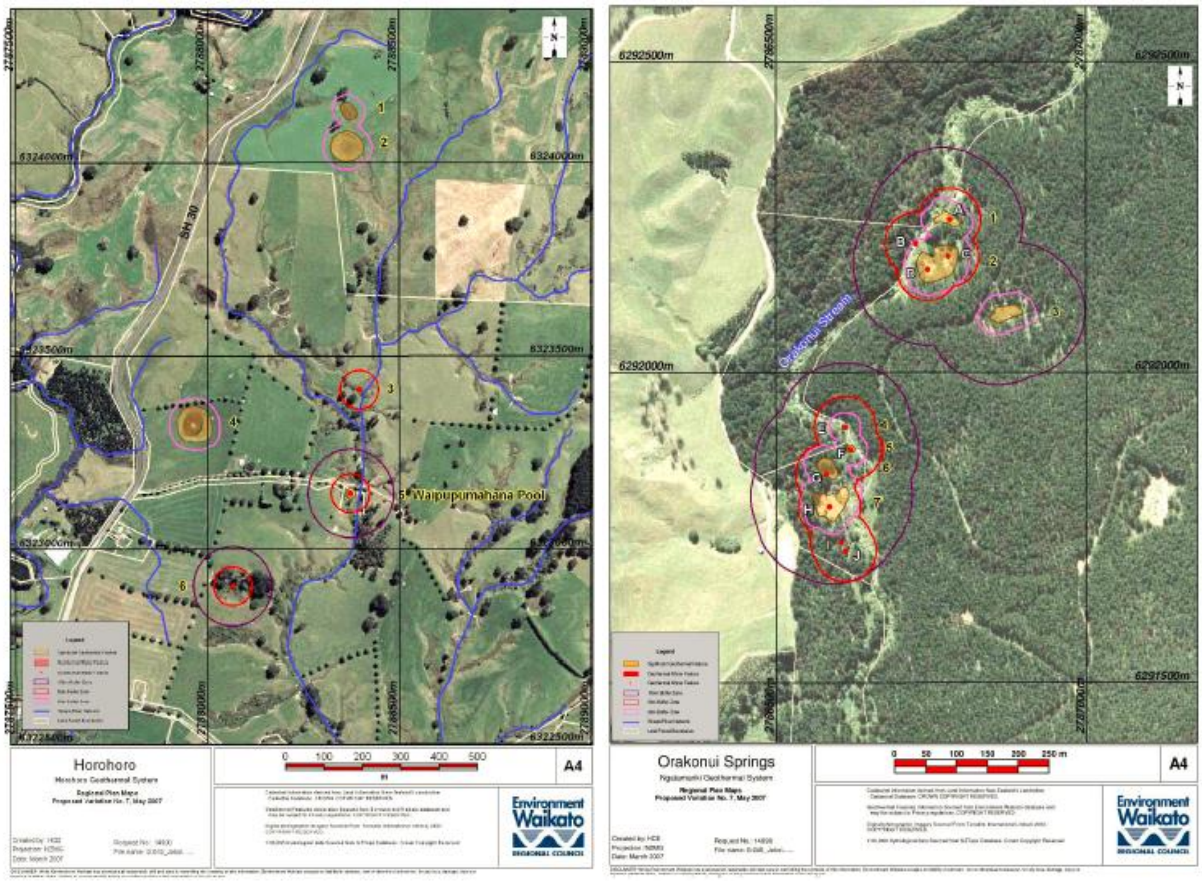

Figure 4-2: Examples of Significant Geothermal Features in the "Development" Category
Left: a part of the Horohiro Geothermal Field, Right: Orakonui Springs in the Ngatamariki Geothermal Field
Source: Waikato Regional Council (2008)

Drilling Data on the Taupo Volcanic Zone according to the Crown and Geothermal System Classification

The Crown carried out drilling surveys of geothermal resources in the country, including the Taupo Volcanic Zone, during the 1970s and 1980s. The data gathered by these drilling programs have been used for regional policymaking, project planning by developers, Resource Consent applications including AEE, and monitoring.

These drilling surveys extensively covered the geophysical, geochemical, geological and ecological aspects of the Taupo Volcanic Zone in order to identify likely areas where high temperature geothermal fluid might be found. Based on the survey results, many high temperature zones were drilled to depths of approximately 1,000 m and the most promising zones were drilled to a greater extent than other areas. For areas with surface features that were considered to be nationally significant, the wells were grouted and no further drilling has been carried out.

The wells drilled by the Crown have been left open in the Mokai, Rotokawa and Ngatamarki areas, which were recognized as especially high potential, and the data are for sale. In addition, negotiations between the Maori landowners of these areas and the Crown have resulted in the transfer of well rights from the Crown to Maori Trusts, which have since formed partnerships with power companies and developed geothermal power stations (discussed later in detail).

The classification of the geothermal systems of the Waikato Regional Council was created using the data and its interpretation gained from the national drilling surveys. The geothermal policy of the Council is based on the concept of geothermal systems, where system boundaries determine the rules that control the activities within them. System boundaries are decided based on resistivity data and other geophysical,

geochemical, geological and ecological data. A large part of the data used for the determination was gathered by the Crown's drilling surveys (McLeod, 2012).
The Waikato Regional Council expects that system boundaries will change, as deeper parts of each geothermal system become better understood through data accumulation and through further developments and drilling. As part of Resource Consent obligation, the Council requires geothermal developers to submit the data on the system gathered by the project and AEE. These accumulated data are then used to update and alter the Council's geothermal policy and rules. For example, the resource assessment and geothermal system boundaries developed in 2002 based on the initial drilling survey data by the Crown are currently in the process of upgrading with the additional data gathered since. System boundaries help developers identify not only the areas that the policy and rules are applied but also landowners and other stakeholders to be contacted to gain access to geothermal resources (Waikato Regional Council, 2002; McLeod, 2012).

Environmental Protection – An AEE in the Resource Consent Process
As mentioned above, many detrimental environmental effects have been caused by previous unregulated development. The ability to predict the environmental effects of development is still limited, and this uncertainty is particularly strong for geothermal resources, which makes the regulator's task more challenging.

The most prominent policy practice for environmental protection is the Resource Consent permission process described in the previous section, which involves substantial analysis and debate regarding what level of protection is appropriate. Because an AEE is processed as a part of the Resource Consent application and review procedure, its details are not specified by the RMA but rather by RPSs and Regional Plans, which makes AEEs different among Regional Councils. In the process of an AEE, the consent authority (Regional and District Councils) processing the application is required to undervalue environmental effects. However, once Resource Consent has been granted, the Regional Council becomes legally bound to ensure adverse effects by the approved projects are avoided, mitigated or remedied.

In order to evaluate an AEE properly, the consent authority requires sufficiently detailed information on the proposed project. This information must be submitted with an AEE and other Resource Consent application requirements to the consent authority. If there is insufficient information, the Council can return the application and the applicant must fill in the information gaps or abandon the proposal. The specific information requirements for an AEE are set out in Schedule 4 of the RMA. The Regional Plan of the Waikato Regional Council sets them as follows:

- A description of the proposal
- An assessment of the actual or potential effects on the environment
- A description of the activity's location as well as alternative locations or methods for undertaking the activity
- A description of how any negative effects on the environment could be reduced (mitigated)
- A list of people interested in or affected by the proposal (including information about the applicant's consultation with them and their views on your activity).
- Any effects that the applicant's activity may have on:
    - The neighborhood and/or wider community (including socio-economic or cultural effects)
    - The physical or visual aspects of the locality
    - Ecosystems including plants, animals and habitats in the area; and
    - Natural or physical resources (aesthetic, recreational, scientific, historical, spiritual or cultural) now or for future generations.
- Additional information if:
    - The applicant is using hazardous substances (include an assessment of risk)
    - The applicant's activity involves hazardous installations (include an assessment of risk)
    - The applicant is discharging contaminants (provide a description of the discharge, where it will be discharged to and possible alternative methods of discharge, including alternative locations)

- The applicant is required to monitor environmental effects (describe how effects on the environment will be monitored and by whom).
  (Waikato Regional Council, 2012c)

The actual amount of information for the above items depends on the situation, but the submission of comprehensive and detailed information is necessary for large-scale geothermal developments. The required information for geothermal Resource Consent applications (including an AEE) is shown in the Appendix. This information needs to be submitted as a part of the Resource Consent application, along with a System Development Plan, Discharge Strategy and computer model of the geothermal system, as described previously.

It is important to note that Regional Councils have broad discretion to allow AEEs to be customized as appropriate for the particular development, and the amounts of information to be included in AEEs are determined by the possible environmental effects of a particular development and by its scale, although the items are predetermined by RPSs. In the case of the Waikato Regional Council, this means that the applicant can focus on matters of significance for the project under the direction of the Council not on an arbitrary list of generic matters. The period necessary to gather all relevant background information for an AEE depends on the amount of already available information; if there is little or no information available for a proposed area and the developer needs to gather it from scratch, the data-gathering process can take five years or more. The time period necessary for the required data gathering or monitoring is not predetermined by the RPS and depends on the conditions of each project. For example, when the geothermal system is remote, the required amount of information would be less than that for the same sized development proposal adjacent to a township or a built-up community. As mentioned previously, ecological data collected by the Crown prior to 1990 were usually fortified by the consent applicant and these have been used in AEEs and for monitoring (Brockelsby, 2012b; McLeod, 2012).

This flexible application of RPSs by Councils is very effective at encouraging developers to apply the most economical and appropriate methods and technologies at a given point. It is also useful for Regional Councils and developers to develop monitoring systems together to observe the environmental effects caused by projects. Such an approach taken in New Zealand does not detail what to do by policy and rules nor force developers to follow the rules regardless of the situations they are in. Instead, it is a results-oriented approach that encourages each developer to take an innovative and practical method by considering the different characteristics of each project and geothermal system, and it is very useful for providing flexibility to users of the institutional system (McLeod, 1995).

The geothermal AEE is generally performed for the following: effects on air quality; effects on water as a result of takes and discharges; effects on land and soil quality as a result of wastewater disposal, earthworks, refuse disposal; effects from well drilling and testing (noise, discharges, odor etc.); effects on surface features and hot ground; effects on groundwater quality; landscape effects; ecological effects; and others. The general conditions that support the need to identify and manage environmental effects include:

- The comprehensive monitoring of the system (by the consent holder) regarding trends in pressure, temperature and chemistry as before
- Reporting and interpreting the information to the Regional Council
- Discharge limits (e.g. for mercury and hydrogen sulfide for discharge into the air)
- Management plans for earthworks, management of hazardous substances, etc.
- Mitigation requirements through consent conditions

(Waikato Regional Council, 2000, 2007; Brockelsby, 2012a)

Once Resource Consent is granted, the Waikato Regional Council requires the ongoing monitoring of the various param mentioned above, and it continually checks the actual trends against what it expects to see. This obligation of ongoing monitoring and reporting to the Regional Council is significant in order to make sure that the applicant meets his/her environmental protection obligations as planned. This system means that gaining the development right through Resource Consent automatically makes the applicant responsible for the environment and the locality. As also mentioned previously, Resource Consent generally requires the establishment of an independent peer review panel to assist the Council in ensuring the sustainable management of the resource (Brockelsby, 2012b). The Regional Plan of the Waikato Regional Council shows objectives, indicators and types of monitoring and information sources for continuous monitoring, as shown in Table 4-1 (Waikato Regional Council, 2008).

Regarding the compensation for damage to local property or natural resource features, the RMA and other laws do not have any clauses that guarantee financial compensation in the case that geysers/hot springs/hot waters become unavailable or unusable due to geothermal power development. The RMA has only a general statement on the purpose of the Act (section 5) that sustainable management includes the "avoiding, remedying or mitigating adverse effects" of proposals. Based on this, when Regional Councils consider that the proposal should proceed but that there is a risk of damage to springs, water supplies or other resources, it will usually include conditions that require the consent holder to remedy such damage (the last item of the above list).

An example is the conditions that require Contact Energy to target reinjection into the ground in the event that certain springs are adversely affected in the Wairakei-Tauhara System. The Resource Consent conditions also require Contact Energy to repair property damage in the same system that occurs as a result of land subsidence caused by its extraction of geothermal fluid. This condition is also supported by a five million NZD bond in the event that Contact is unwilling to take responsibility for the property damage or unable to undertake the necessary repairs. Contact Energy was responsible for raising this bond, which is lodged with and held by a financial guarantor.[6] It is payable to the Waikato Regional Council in the event that Contact Energy does not perform its obligations according to the specified consent condition(s). The Resource Consent conditions can also adjust the amount of the bond over time according to inflationary increases. These types of bonds are prepared and provided for by the RMA, meaning that they persist after the end of the activity to which they relate. Such bonds are rare, however, and this is the only one currently in place for geothermal operations; they are commonly held for mining operations. Although the Regional Council usually initiates bond issuance through the Resource Consenting process, it can be also proposed by developers as a means of mitigating effects or community concerns about effects. The bond requirements are simply another condition of the consent that is granted (Brockelsby, 2012a, 2012b, 2012c). Besides requiring such bond issuance, the RMA allows Regional Councils to impose Resource Consent conditions that require financial contributions, registered covenants and the payment of special administrative charges (McLeod, 1995).

[6] This is usually a bank.

Table 4-1: Monitoring Options for the "Development" Category in the Waikato Regional Plan
Source: Waikato Regional Council (2008)

Objective	Indicators/ Measurement	Type of Monitoring	Information Source
Where geothermal energy and water is taken, it shall be used and managed efficiently.	Trends in the total amount of geothermal energy and water extracted, converted and injected, reinjected or discharged, in and from geothermal systems.	Resource use monitoring, compliance and effects monitoring, reservoir modeling.	• Surveys and compliance monitoring database. • National energy use surveys. • Resource consent • Reservoir modeling.
In Development Geothermal Systems, significant adverse effects on Significant Geothermal Features arising from the take of geothermal energy and water to be remedied or mitigated within the Regional Geothermal Resource.	The trend in the number and condition of the various geothermal features and characteristics.	Regional monitoring of and regular reporting on the state of and threats to different geothermal features and characteristics	• Geothermal database and Resource Consent database.
Significant adverse effects on Significant Geothermal Features arising from land use and the take, use and discharge of non-geothermal water to be avoided.	GIS comparisons of mapped extent of Significant Geothermal Features	Aerial mapping, supported by ground survey and site inspections	• District Council Consent applications and databases • Five yearly aerial photography
In Development Geothermal Systems, adverse effects on other natural and physical resources including overlying structures (the built environment), such as those resulting from subsidence and land instability, arising from the take, use, and discharge of geothermal energy or water to be avoided, remedied or mitigated.	Subsidence rate in excess of natural rate.	Ground level surveys	• Subsidence monitoring by developers linked to consent conditions
Significant adverse effects on freshwater and land arising from the discharge of geothermal energy and water avoided.	See Section 3.1.4. (Water Resource Monitoring Options)	See Section 3.1.4. (Water Resource Monitoring Options)	See Section 3.1.4. (Water Resource Monitoring Options)
Increased knowledge about the Regional Geothermal Resource and better understanding of the effects of using the resource and effects of other activities on the resource.	All the above indicators	As above	All the above indicators

Databases are required to manage and operate the Resource Consent application and monitoring process. Regional Councils create databases to hold the necessary data and manage them for each Resource Consent application. One such database is the Resource Consent Database seen in Table 4-1. This database holds data about Resource Consent (type, description, reference number, name and address, physical location, relevant dates such as granting, commencement, expiry dates, as well as having links to relevant documents such as an application/AEE, decision, notification and copies of the Resource Consent). Another database is the Compliance Monitoring Database, which supports monitoring compliance by consent holders and includes data such as the details of every Resource Consent, including the conditions, and supports the creation of compliance audit reports and other information relating to compliance monitoring. These databases are not open to the public. All staff members at Regional Councils have access to them, but only relevant staff members can edit them (Brockelsby, 2012c).

Currently, the Waikato Regional Council is preparing a new database system called the IRIS system, which will merge the above two database systems. This IRIS system not only holds these databases but also adopts a system that supports interactive workflows into the Resource Consent process. With the purpose of fortifying Regional Council functions and processes, six Regional Councils including Waikato have been developing the IRIS system. It has a total budget of five million NZD. The Councils have outsourced the development of the system to the Datacom Corporation, and the annual operation and maintenance (O&M) costs are expected to be one million NZD. The six Councils will share system development and these annual O&M costs (Brockelsby, 2012c).

National Database for Geothermal Systems

The database that all developers can access for various drilling and environmental data gathered from national drilling surveys and previous developments is yet to be built. Currently, the Crown owns and manages all data gathered from past drilling and research, and all such data are available for anybody who pays a certain price. Right now, developers must gather all necessary background data for project planning by themselves, and this can be carried out by either purchasing the drilling data owned by the Crown and/or by carrying out drilling and research by themselves. The latter data-gathering method requires Resource Consent for drilling and approval. In fact, the data owned by the Crown is useful, as it covers a wide spectrum. However, developers usually must drill new wells beyond those drilled by the Crown in order to gain confidence in the economic potential of the resource (Brockelsby, 2012d; McLeod, 2012).

Currently, there is a movement to build a national database accessible by the Crown, Councils, developers, investors and the public. The Crown is considering making its own geothermal data gathered from drilling surveys during the 1970s and 1980s available in order to revitalize the New Zealand economy by enhancing the understanding of the resources and encouraging the development of geothermal commercial projects. This involves multi-year efforts.

The database will include all drilling data, meaning that it involves drilling data that are not usually open to the public. This requires Resource Consent requirement for data/information disclosure and could be likely area of tension between the Councils and developers. However, the Crown Minerals Act of New Zealand already requires all resource data to eventually be made open to the public, and it is considered that there will be no differences for geothermal resource data.

All resource data will be included in the national database, including well data, survey data, conceptual model and computational model data, ecological data and landownership data. Data on the environment, context of the resource and context of the takes and discharges are also expected to be available in the database, although data associated with what is happening within power stations or other plants are not expected to be in the database. One of the current problems is that the Crown does not know what data it owns, or in some cases where the data, information and materials are being held. The other issue is building a federated open data infrastructure for such a national database. The Waikato Regional Council has commissioned model development works related to this issue (McLeod, 2012).

3) Section Summary

Previous detrimental environmental problems in New Zealand were caused by a lack of knowledge and experience in large-scale geothermal resource development. However, the lessons learned from this unregulated and unsustainable geothermal development have brought about important changes to the regulations and policy as well as development practices in the country.

As current knowledge and technology cannot ensure the reduction of the uncertainties surrounding the sustainability of geothermal resources, clear institutional frameworks for AEEs and their flexible application are important to balance development needs and environmental protection. While the Resource Consent authority avoids excess burdens on applicants by customizing AEE based on project situations, the obligation of the ongoing monitoring and reporting of environmental performance after the project becomes operational functions as a means of ensuring the applicant fulfills its duty to the environment and locality. In addition to such monitoring, reporting and assessment overseen by independent third-party experts, the reinjection of fluid to the field is a common practice to avoid the land subsidence caused by the over-extraction of geothermal resources. Staged development also enables the sustainable usage of resources by both the local Maori community and developers, as well as reducing initial development risks by phasing risky resource development. The institutional system, which allows for the flexible application of the policy and rules, and a results-oriented approach encourage developers to apply the most economical and appropriate method and technologies at a given point, with a consideration of the different characteristics of each project and geothermal system. Thus, it is useful for offering flexibility to users of the institutional system. The important aspect is to make these procedures standard business practices by stipulating them in regulations and policy.

5. Cooperative Relationship Building with the Local Maori Community

1) Maori, Geothermal Resources and Maori Trusts

Relationship building with landowners who provide access to geothermal resources is crucial in New Zealand, as many such locations are owned by the indigenous Polynesian people called Maori, who comprised 15.3% of the total New Zealand population in 2011 (Statistics New Zealand, 2012a, 2012b). They consider themselves to be mere custodians of the land and have always been closely affiliated with geothermal resources, which they have used for bathing, cooking, preserving, therapeutic purposes and ceremonial usages for centuries. Geothermal resources are thus considered to be crucial and treasured by Maori people. However, the recent large-scale development and extraction of geothermal fluid and/or heat for industrial and private purposes have depleted fluids in some systems and caused the disappearance of many hot pools, threatening sacred Maori sites near geothermal areas.

Since the start of the colonization of New Zealand by Europeans in the 17th century, and after many twists and turns over disputed land sales, Maori still have retained the ownership of large tracts of their traditional lands. In the high temperature geothermal system areas of North Island, each block of many of these lands is owned by Maori landowners. In many cases, these owners collectively establish Maori Trusts to manage these lands for the benefits of owners.

A Maori Trust is a means to enable Maori land possessed by multiple owners to be developed and used for owners. The objectives of the Trust vary among different Trusts. Owners nominate Trustees and the Maori Land Court appoints them. The Maori Land Court does not have to accept these nominations. Trustees are obliged to deal with Trust property for the benefit of beneficiaries. The Maori Land Court also has the power to remove an existing Trustee or terminate the Trust. In addition, although Maori Trusts may own Maori freehold land or general land, or can mortgage Maori freehold land, the sale and transfer of Maori freehold land by all trusts is restricted (Lincoln University, date unknown).

In general, Maori Trusts offer many advantages to landowners, including providing a management vehicle for multiple ownership blocks; providing economies of scale; providing ease of operation and faster decision-making through a formal internal management structure; providing systematic ways to deal with the succession problems of Maori freehold land; and increasing negotiating power. Some disadvantages include delayed decisions by going through this formal structure and process and strong control by the Maori Land Court.

Regarding the employment and livelihood of Maori people, there were 439,600 Maori people over 15 years in New Zealand as of March 2012. In the year to March 2012, 66.3% of this working-age population was in the labor force, while 33.7% was not due to reasons such as child rearing, retirement or studying. This ratio is slightly lower than the labor force rate of the entire New Zealand working-age population (68.4%). Meanwhile, the unemployment rate of Maori is always higher than the total employment rate of New Zealand. After the recent financial crisis, while the unemployment rate of Maori has stayed at approximately 14%, the total employment rate of the country is under 7%. These gaps are increasing. In the year to March 2012, the leading industries in which Maori worked were manufacturing and wholesale & retail, followed by health care & social assistance. The largest occupational group of Maori is “Labor” and more than 54% of employed Maori belong to this category. The next largest occupational group is “Professional,” followed by the “Manager” group. This shows that Maori people are not mere laborers (New Zealand Department of Labour, 2012). These statistics demonstrate that very few Maori people make a direct living from geothermal resources or development, unlike many local people around geothermal development in Japan, which are making livings from the hot spring business.

Table 5-1: Maori Employment by Industry
New Zealand Department of Labour (2012)

Industry	Number	%
Agriculture, Forestry, Fishing & Mining	22700	9.0%
Manufacturing	38100	15.1%
Utilities & Construction	23700	9.4%
Wholesale & Retail	28800	11.4%
Accommodation & Food Services	15300	6.1%
Transport, Warehousing & Communications	18700	7.4%
Financial & Insurance	3900	1.5%
Other Business Services	20300	8.0%
Public Admin & Safety	17000	6.7%
Education & Training	23100	9.1%
Health Care & Social Assistance	27000	10.7%
Other Services	13400	5.3%
Not Specified	700	0.3%
Total Employed	252700	100.0%

Table 5-2: Maori Employment by Occupation
New Zealand Department of Labour (2012)

Occupation	Number	%
Managers	28000	11.1%
Professionals	42000	16.6%
Technicians & trade workers	28000	11.1%
Community & personal service workers	28500	11.3%
Clerical & administrative workers	26000	10.3%
Sales workers	18200	7.2%
Machinery operators & drivers	26600	10.5%
Labor	54200	21.4%
Others	1200	0.5%
Total Employed	252700	100.0%

2) Necessity for Collaboration

For geothermal resource development for power generation, developers have increasingly recognized the need to build good relationships with Maori landowners and their Trusts, the key stakeholders who provide access to valuable resources. Although the sub-surface geothermal fluids under either public or private lands do not belong to anyone (no ownership), being able to apply for Resource Consent requires having access to these resources through landownership or agreement from landowners. At the same time, it is crucial for developers to recognize the social, financial, environmental and cultural benefits for landowners, in particular, considering the historical hardships suffered by Maori for the past 200 years.

Moreover, the RMA 1991 specifies that "the relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu[7] and other taonga[8]" is one of five matters of national importance. The RMA also requires the Treaty of Waitangi to be considered. The Treaty of Waitangi was signed between the Crown and Maori representatives in 1840 to establish equal status and the protection

[7] A sacred place.
[8] A treasured thing.

of the Maori population under the British rule. Thus, the statutes require good relationships with Maori people in geothermal resource development (New Zealand Government, 1991). As a result of these practical reasons and statutory requirements, diverse project ownership models with Maori in geothermal projects have been developed through collaborations between developers and Maori landowners. Table 5-3 shows the partnerships formed with Mighty River Power.[9]

Table 5-3: Geothermal Partnerships between Mighty River Power and Maori Trusts

Mighty River Power (2011); McLoughlin et al. (2010)

Geothermal Power Station	Size (MW)	Commission Year	Region	Maori Partners	Ownership Structure
Mokai	112	2000	Waikato	Tuaropaki Trust	Tuaropaki Power Company (TPC) (Tuaropaki Trust 75%; Mighty River Power 25%)
Rotokawa	34	1997	Waikato	Tauhara North No. 2 Trust	Mighty River Power (100%)
Nga Awa Purua	140	2010	Waikato	Tauhara North No. 2 Trust	Nga Awa Purua JV (Tauhara North No. 2 Trust 25%; Might River Power 75%)
Kawerau	100	2008	Bay of Plenty	Ngati Tuwharetoa (Bay of Plenty) Settlement Trust Putauaki Trust Norske Skog Tasman*	Mighty River Power (100%)
Ngatamariki	82	proposed	Waikato	Tauhara North No. 2 Trust	Mighty River Power (100%)

Note*: Norske Skog Tasman is not a Maori Trust but a pulp and paper company that has been using geothermal steam for heat and power for its mill in the Kawerau area since the 1950s.

Recently, Contact Energy also announced a partnership with the Tauhara Moana Trust for the Taupo area (Contact Energy, 2011). This is a long way from the 1950s when there was no Maori involvement in the first geothermal development and even from the early 1990s when Maori involvement in the Ohaaki geothermal power development sponsored by the government was limited only to the lease agreement for the land. The following introduces three examples, Mokai, Rotokawa and Nga Awa Purua, from Table 5-3, and the Wairakei power station operated by Contact Energy. Figure 5-1 shows the locations of these four projects.

[9] The Electricity Reform Act of 1998 broke up the ECNZ into three SOEs. Mighty River Power is one of them. The firm is the only SOE that has developed geothermal business and a professional geothermal team.

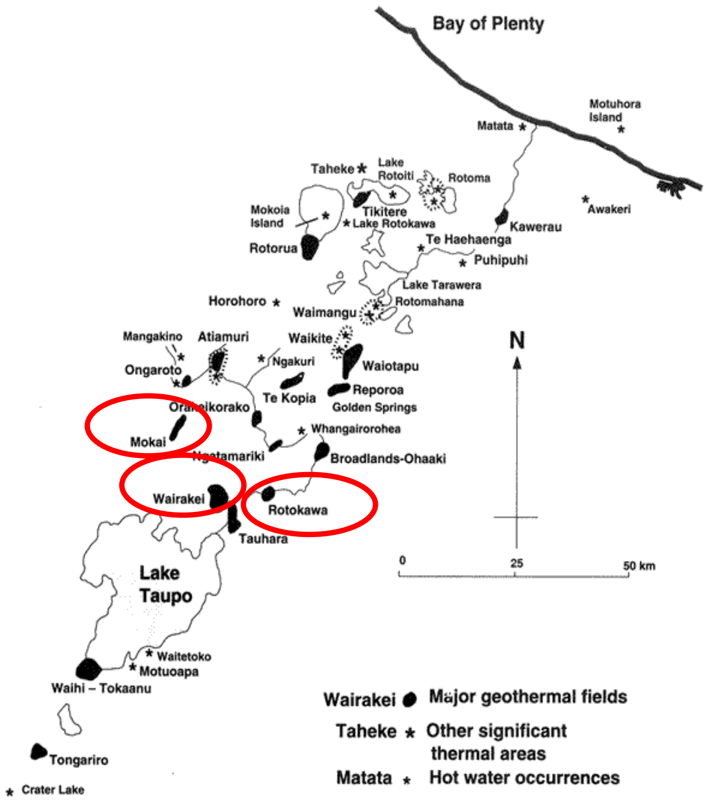

Figure 5-1: Locations of Mokai, Rotokawa, Nga Awa Purua and Wairakei in the Taupo Volcanic Zone Geothermal Field

Note: Both the Rotokawa and the Nga Awa Purua geothermal plants are located in the Rotokawa field.

Source: drawn by the author from NZGA 2012a

3) Example 1: Mokai Power Station


Photograph: Mighty River Power
http://202.74.224.54/Generation/PowerStations/Geothermal/Mokai/Gallery.aspx
Location: Northwest of Taupo
Original Commission Date: February 2000
Capacity: Original capacity of 55 MW, 40 MW expansion in 2005 and 17 MW expansion in 2007, current capacity (2011) of 112 MW

Technical Features: Combined Cycle of a Steam-binary Turbine and Lower-temperature Brine Unit connected to a Binary Turbine

The Tuaropaki Trust has 1,700 Maori shareholder-owners and 3,900 hectares of land 30 km northwest of Taupo. It is the majority owner of the Tuaropaki Power Company Limited (TPC), which owns the Mokai geothermal plant. Besides the geothermal power generation business, which occupies 30 hectares of land, the Trust also engages in the commercial business of temperature-controlled horticulture (25 hectares of land), farming (the remainder of the 3,900 hectares of land) and the provision of broadband internet to remote areas in New Zealand. The profits made by these businesses are used to benefit the shareholders through education grants and scholarships (Tuaropaki, 2012).

A substantial geothermal resource was found in the Mokai area in the Taupo Volcanic Zone when the Crown drilled investigation wells in 1982 and 1983. In 1994, the Tuaropaki Trust established a 100% subsidiary TPC in order to generate and market the electricity from this Mokai geothermal resource. Resource Consent was granted by the Waikato Regional Council in the same year. The Tuaropaki Trust purchased the Crown's right in the wells in 1996, and it has since been engaging in developing the resource in stages.

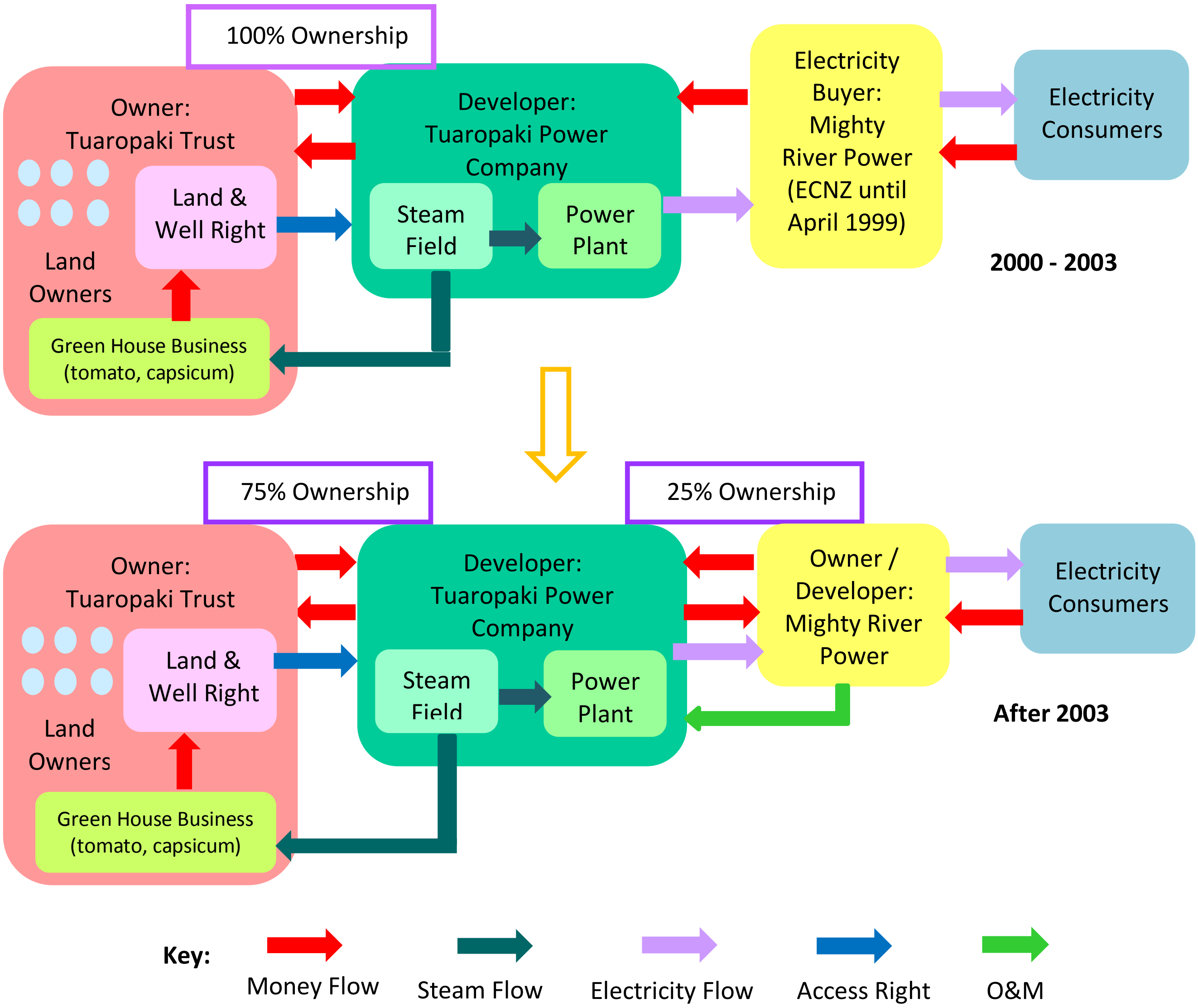

Figure 5-2: Mokai Power Station Business Model

The Mokai Power Station, the first power station fully owned by a Maori Trust, was commissioned in 2000. This Trust is known to be the first indigenous group in the world to raise finance for such a project. The TPC was owned 100% by the Trust until 2003 when 25% of the share was acquired by Mighty River Power.[10]

The power generated by the Mokai plant is sold to Mighty River Power, which is given the right by the Tuaropaki Trust to extract up to 40,000 tons of geothermal fluid per day, operate and maintain the steam field, power plant and transmission system, sell the power to consumers and provide long-term price support for power sales. The contractual arrangements with Mighty River Power, including both shareholding and extracting rights, will expire in December 2027, when 100% of the ownership of the TPC will revert to the Tuaropaki Trust (Lincoln University, Date Unknown; Tuaropaki, 2012).

The Trust aims to minimize adverse environmental effects and accommodate the needs of existing users as well as the potential needs of future generations by staging its geothermal development activities. The reinjection of fluid into deep geothermal aquifers, the key practice for sustainable development, is carried out to minimize the impacts on existing geothermal features and natural ecosystems. The Trust has also produced tomatoes and peppers for export by utilizing the steam for heated glasshouses, and it employs 50 people from Mokai and Mangakino, most of whom were previously unemployed. This has significant socio-economic effects on the two areas (Waikato Regional Council, 2012b).

4) Example 2: Rotokawa Power Station

Photograph: Mighty River Power
http://202.74.224.54/Generation/PowerStations/Geothermal/Rotokawa/Default.aspx?id=1422
http://202.74.224.54/Generation/PowerStations/Geothermal/Rotokawa/Gallery.aspx
Location: Northeast of Taupo
Original Commission Date: 1997
Capacity: Original capacity of 28 MW, 6 MW expansion in 2003, current capacity (2011) of 34 MW
Technical Features: Combined Cycle of a Single Flash (high-pressure steam) and Binary System (low-pressure exhaust steam)

Similar to the Mokai geothermal field, the Rotokawa geothermal field was also discovered by governmental drilling during the 1950s in the Taupo Volcanic Zone. The Tauhara North No. 2 Trust (currently 655 shareholder-owners and eight elected trustees) owns a land block of both the Rotokawa Power Station and the Nga Awa Purua Power Station in the zone. The owners currently collectively own 326 hectares of the originally owned 4,000 hectares of land. Since the 1990s, the Tauhara North No. 2 Trust has developed separate Joint Ventures with Mighty River Power for geothermal development.

[10] Because Mighty River Power was incepted in 1999 as a result of the ECNZ split, the original buyer of the power was the ECNZ.

The first project for the Trust was the Rotokawa project commissioned in 1997 with a capacity of 32 MW. The project was divided into two Joint Venture companies: the Rotokawa Joint Venture (50:50 Joint Venture between the Tauhara North No. 2 Trust and Mighty Power River), which owns the steam field; and Rotokawa Generation (currently 100% owned by Mighty Power River, two Directors from the Tauhara North No. 2 Trust), which owns the power generation plant. Originally, the Rotokawa Power Station was owned by a third party, but the Tauhara North No. 2 Trust invited Mighty River Power to take ownership of the plant, which was purchased by it in 2000. Mighty River Power operates both the station and the steam field.

The Trust opted out of shareholding the power station, and took only a 50% share of the steam field Joint Venture along with a monthly royalty payment. The reason was its limited commercial experience relating to equity ownership as well as its limited financial resources. Despite no financial involvement, the Trust represents two of the five Directors for the Rotokawa Generation Ltd. Annual royalty payments to the Trust are approximately 700,000 NZD and there is no capital risk (McLoughlin et al., 2010).

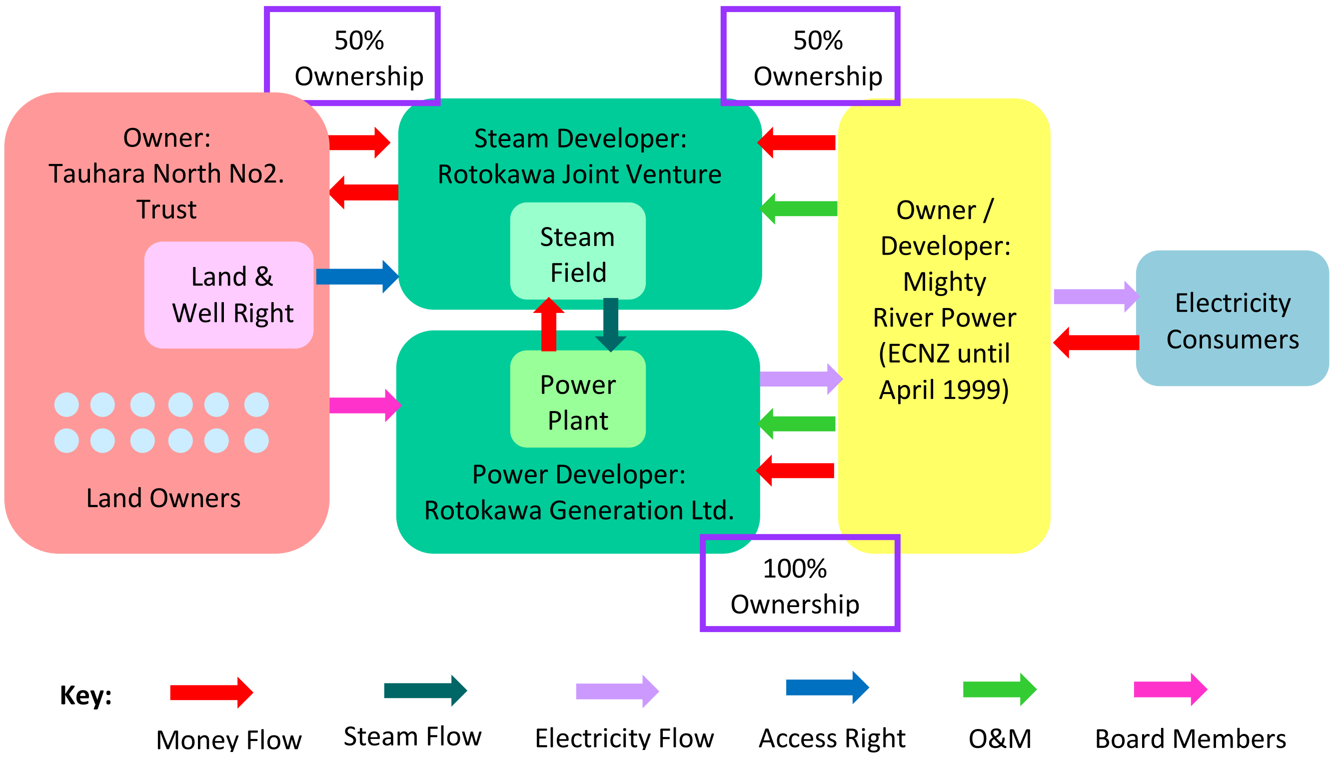

Figure 5-3: Rotokawa Power Station Business Model

5) Example 3: Nga Awa Purua Power Station

Source of Photograph: Tauhara North No. 2 Trust 2009
Mighty Power River
http://202.74.224.54/Generation/PowerStations/Geothermal/NgaAwaPurua/Gallery.aspx
Location: Northeast of Taupo
Commission Date: 2010
Current Capacity: 140 MW
Technical Features: Triple-flash configuration utilizing high, intermediate and low-pressure steam inlets, accommodating the largest single-shaft, custom-made geothermal turbine in the world

The Nga Awa Purua Power Station project is the best example to date for a collaboration between developers and Maori landowners. Ten years of good performance of the Rotokawa Power Station gave enough confidence to the Tauhara North No. 2 Trust and Mighty River Power for the incremental expansion of a second power station in the Rotokawa field (Mighty River Power 2010b; Power-technology.com 2012).

Joint Venture Negotiation and Agreement

The informal negotiation process was already underway in 2005 and continued as each party proposed various options. The formal negotiation process started in May 2007, and the Key Commercial Term Agreement was reached one month later (June 2007) after a two-day meeting with the senior leaders of both sides along with their commercial and legal advisors. The Key Commercial Agreement eventually led to the establishment of the Nga Awa Purua Joint Venture in October 2010. These processes helped both sides fully understand the values that each party brought to the project (McLoughlin, et al., 2010; McLoughlin, 2012). The main agreement was that Mighty River Power would deliver the expertise and initial capital investment to the project, while the Tauhara North No. 2 Trust would offer the land and support for Resource Consent. As Mighty River Power provided the initial capital with the majority ownership of the project, the Trust had the opportunity of buying into the project upon commissioning; hence, there was no need to provide project capital and equity investment for construction. Further, the Trust receives a royalty from the project revenues[11] (McLoughlin, et al., 2010).

[11] McLoughlin et al. (2010) detailed the final Joint Venture agreement, which did not have significant changes from the Key Commercial Agreement.

After the Key Commercial Agreement in June 2007, the Trust began a series of extensive meetings. At these meetings, technical and commercial consultants helped Trust owners understand the project implications by advising on the ownership and commercial structures necessary for the project, including protection of land assets and benefit flows, the risks involved geothermal exploration and the technical characteristics of geothermal projects. As a result of such efforts, 95% of known shareholders of the Trust supported the project at the end[12] (McLoughlin, et al., 2010).

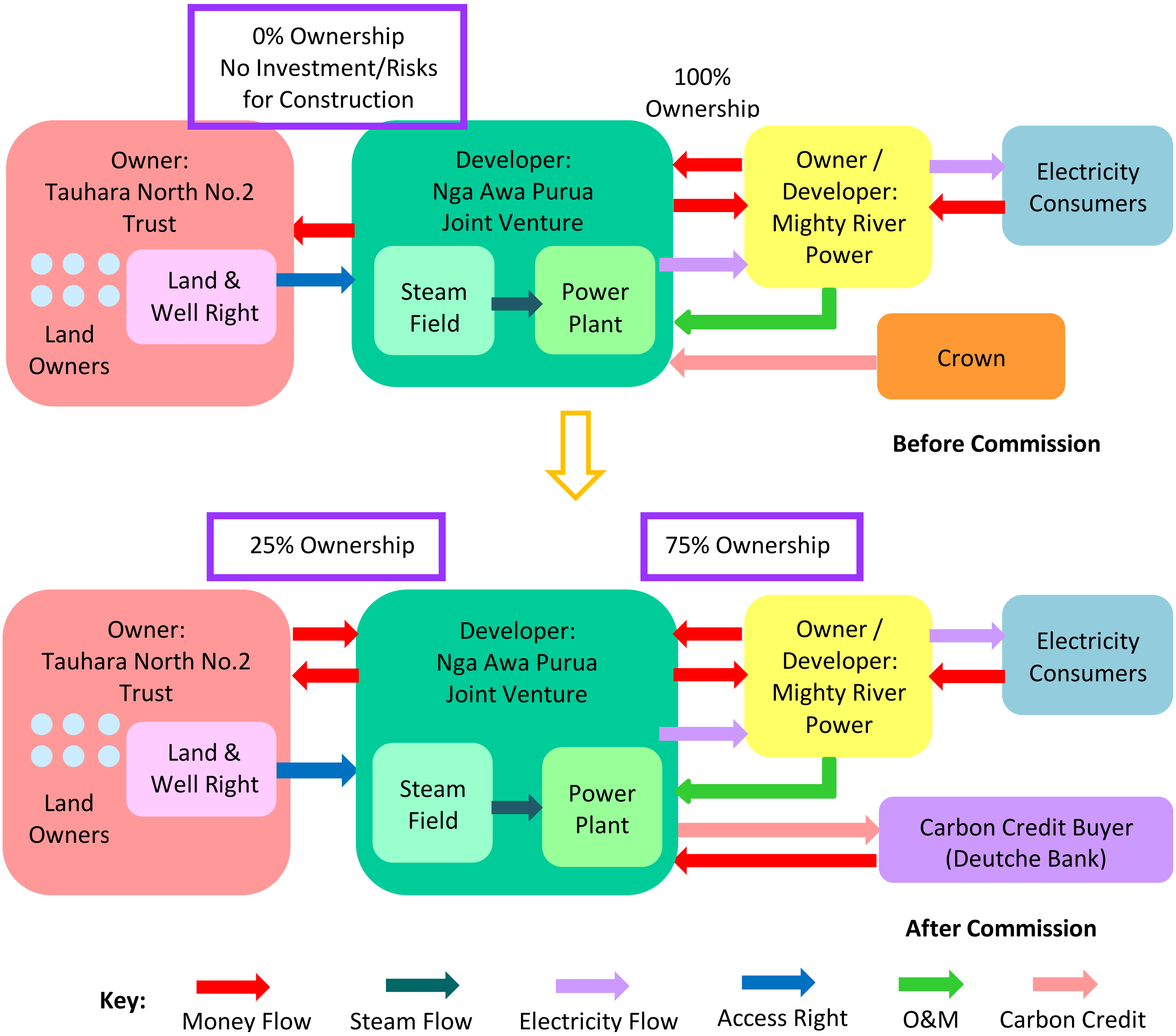

Figure 5-4: Nga Awa Purua Power Station Business Model

[12] The Maori Land Court required evidence of support for the project from over 50% of owners for the long-term lease arrangement. At the beginning, only 35% of known shareholders showed support for the project (McLoughlin et al. 2010).

Maori Collaboration for Resource Consent

With the amicable financial arrangements provided by Mighty River Power (continuous royalty payments and initial 100% capital risk) in place, the Trust assisted the developer attain Resource Consent by soliciting project support from neighbors and making submissions to various Consenting Authorities. This helped shorten the Consenting process considerably to less than seven months from the usual 12 to 24 months. The entire process helped the Trust and landowners understand the risks and benefits of geothermal power development, and deepened mutual trust (McLoughlin, et al., 2010).

Finance

The most important precondition by the Trust to the banks was that it would offer no form of security over its land to avoid any forfeiture and commercial default risk. However, as this precondition was rejected by the three banks approached by the Trust, the Trust offered security over the royalty stream as well as a General Security over the interest in the Joint Venture as an alternative and the banks accepted these terms and provided 100% of the financing of the Trust's equity investment.[13] The banks also imposed agreements that required the building up of reserves for capex and debt servicing as well as the regular reporting of key financial ratios, which were the result of communication between the Trust and banks. Such communication enhanced the Trust's understanding of long-term investments and the importance of building relationships with financers. This contributed to Trust business further, making lenders strongly compete for 100% debt funding for the Trust to buy its share of the Joint Venture project later, despite the recent global financial crisis (McLoughlin, et al., 2010).

Transparency

There was a concern over the transparency of geothermal power pricing that stemmed from a conflict of interests within Mighty River Power, which sells the power at the highest possible price, while one of its subsidiaries has the opposite aim of buying power at the lowest possible price. Under this condition, in order to ensure the fairness of the price that the Joint Venture receives for selling its power, the Trust implemented various transparency measures in order to provide enough confidence in the forward revenue stream to satisfy lenders and to maintain a sufficient return for the Trust (McLoughlin et al., 2010).

Difficulties

McLoughlin (2012) reported that the most difficult part of the formation of the Joint Venture was convincing the Maori owners to agree on the exploitation of the geothermal reservoir. There was a strong historical reason for the concerns from owners' perspectives.

The Ohaaki Geothermal Power Plant development, which was also developed on Maori land by Contact Energy, caused the gradual sinking of land, which subsequently induced the Waikato River to flood the Maori community following the first drilling of the geothermal production well in the area more than 30 years ago. Despite persisting sinking problems, the project gained development permission and the Ohaaki plant was commissioned in 1989. However, this station caused the further dropping of ground level by about 3.5 m because of the compression of underground strata about 100 m below ground level due to the extraction of steam. Two Maori Trusts, including the Tauhara North No. 2 Trust, were affected, and they thus established the Ohaaki Marae Working Party in 2003 with Contact Energy to deal with the problem. The Ohaaki Marae area finally agreed to be relocated in 2009 (Land Information New Zealand 2009; Ohaaki Marae Working Party, 2012).

This long-lasting ordeal caused by a geothermal plant made the shareholder-owners of the Tauhara North No. 2 Trust understandably quite apprehensive. This situation was turned around by the independent technical advice obtained from Sinclair Knight Merz (SKM). SKM offers consulting, engineering and project

[13] The banks saw the project as low risk because: 1) the Trust could choose not to buy-in if the plant did not meet expectations; 2) the project partner was Mighty River Power, which had the full backing of the Crown; and 3) the project financials were very strong with a relatively short period of expected time for debt repayment by the Trust.

delivery, and it was appointed by the Ohaaki Mare Working Party as an independent peer reviewer to conduct research on the sinking problem in the Ohaaki Marae area. SKM gained strong confidence from the subsidence and flood-related analysis of the Ohaaki Marae Working Party, and it further conducted independent third-party analysis of Nga Awa Purua for the Tauhara owners. This convinced them that technology and the understanding of reservoir management had grown since the Ohaaki geothermal development and that the same mistakes would not be made on their land (McLoughlin, 2012; Ohaaki Marae Working Party, 2012).

The second most difficult issue identified by McLoughlin (2012) was convincing the owners to take out a huge bank loan to finance the equity purchase of the project. The unfamiliarity and lack of sophistication regarding financing made the Trust worry about the implications of financial failure. This was alleviated by good communication with trustworthy professionals, which provided cautious advice and a transparent explanation of the financial model.

The other difficulty was reducing the gaps in information and understanding with Mighty River Power. Originally, the owners of the Trust were afraid of Mighty River Power controlling the Trust's destiny. Again, the Trust hired top experts in the field as independent third-party appraisers to evaluate the proposals and explanations by Mighty River Power. This advice raised the levels of Trust understanding in both technical and legal terms and contributed to successful relationship building with Mighty River Power (McLoughlin, 2012).

Benefits and Shortcomings

Both the Trust and Mighty River Power have benefitted from the project. Besides a new and low-carbon emissions power plant, this project brought about a huge symbolic meaning by demonstrating that the amicable and fruitful collaboration between the government (the SOE Mighty River) and Maori people was possible despite the unfortunate history.

The project brought about significant benefits to landowners as well. McLoughlin (2012) specified the purposes and reasons for forming the Joint Venture, ranking from the most important. These were 1) providing the Trust shareholder-owners with an improved standard of living; 2) providing a fund to benefit the future generation of owners; 3) creating a sense of achievement and success within owners; 4) creating legal documents that protect the Trust investment; and 5) providing an entity into which the Trust could measure performance from a financial perspective and actively invest. While these original purposes were well achieved, the Trust does not see any shortcomings.

The profits of the Trust have not been limited to ordinary power sales and royalty payments; they include the sales of carbon credits. In 2004, the Joint Venture acquired rights to up to 791,000 Projects to Reduce Emissions (PRE)[14] schemes from the Crown. The Nga Awa Purua plant earned 410,000 Emissions Reduction Units from this PRE scheme for the first year of operation, which were sold by the Joint Venture to Deutsche Bank AG for 9.3 million NZD (eight million USD) at 22.78 NZD per unit in 2011 (THINKGEOENERGY, 2011).

[14] The PRE scheme was launched by the New Zealand government in 2003. Two rounds of tenders were carried out in 2003 and 2004. The third round is not planned by the government at this point. There are 34 projects in the PRE scheme. It requires participating projects to reduce emissions beyond business-as-usual reduction goals, while emissions reductions must occur over the first commitment period of the Kyoto Protocol (2008–2012). The PRE provides emissions units, or "carbon credits," which can be traded internationally and add to the financial value to the project. The emissions earned by the PRE scheme can be sold on the international or domestic markets either to governments or to private buyers at market price at the time of selling (MfE, 2012d).

6) Example 4: Wairakei Power Station

Resource Consent applicants need to engage in a consultation process with affected parties under the RMA, although this is not compulsory by law. As illustrated by the three Mighty River Power–Maori Joint Venture examples, this is very important in relationship building with the local community.

Source of Photograph: Richard Seaman
http://www.richard-seaman.com/Wallpaper/NewZealand/NorthIsland/WairakeiGeothermalPowerStation.jpg
Location: North of Taupo
Commission Date: 1958
Current Capacity: 181 MW
Technical Features: Wet steam plant (the original main plant). Binary plant addition in 2005 to utilize low temperature steam from the main plant

The Wairakei Power Station originally commissioned in 1958. As mentioned previously, this early development caused various environmental problems. To this day, some issues remain with local residents and landowners. In 2004, Contact Energy was applying for re-consent of the station in order to add a binary plant to utilize the low temperature steam from the main wet-steam plant. The firm engaged in a series of community relations efforts.

Information Provision and Personal Engagement

The first effort was to post a pre-application summary document to all local residents. This document was prepared carefully, so it was easily understandable and concise, explaining the project, the results of the assessment of the project effects to the local environment and people and how certain actual or potential effects were to be avoided, remedied or mitigated. Informing local residents before an actual application is filed is a basic requirement to start good relationships with the affected parties. Contact Energy also held an open day at the power station to show people round, let them ask any questions and provide a comments box for further discussions. These questions and comments were then personally followed up. Contact Energy actually visited people's homes and engaged in discussion to solve the issues raised by residents.

The Waikato Regional Council appreciates such efforts by Contact Energy for limiting the spread of rumors and misinformation; providing people with real data and information enabled them to seek more information and follow-ups. Further, the personal follow-up process enabled one-on-one engagement, which made people feel that they were being listened to. This also helped demystify complex processes and issues and solve issues in practical ways (Brockelsby, 2012a).

7) Section Summary

The New Zealand geothermal industry has to collaborate with the Maori people to gain property and/or land access for geothermal development, as a large share of the lands above geothermal resources is owned by these indigenous people. Historically, there have been numerous property disputes and conflicts between Maori and immigrants from Europe and serious environmental problems caused by geothermal development on Maori lands. These conditions have forced geothermal developers to create ways to work with Maori. Joint Venture formation with the provision of financial rewards, information sharing and personal and communal engagements have been useful to build amicable relationships between developers and Maori.

Staged development benefits both Maori landowners and developers, as they enable sustainable resource management, reduce project risk and accommodate the diverse needs of both sides. The formation of Joint Ventures has been useful, as the arrangements are carefully made to guarantee financial rewards and mutual understanding. Financial rewards are crucial, as they can be used for diverse purposes by landowners (the Trust) and reward landowners for their risk-taking behaviors in terms of lending land and well rights. Commercial project experiences also help Maori people understand and participate in long-term investment, contributing to their capacity building.

Good communication, openness and transparency, flow of information, independent expert advice, personal engagements and follow-up are all important to build trust between developers and Maori landowners. Such a process is vital for understanding both mutual values and the technical aspects of each project.

Continuous and repeated collaborations between the Maori population and Mighty River Power increased the trust between them and benefitted the developer as Maori increasingly collaborated with it to reduce lead-times and costs. These collaborations also benefitted Maori as they created continuous cash flows. The increasing trust between them can be seen in changes in the ownership structures of jointly owned development companies over time. In the initial arrangement of the Mokai Power Station, Mighty River Power did not have any share or stake in jointly-owned development companies in 1994. This changed in 2003 when the firm gained a 25% ownership. In the Rotokawa project, Mighty River Power had 50% of the Joint Venture company from the beginning. As for the Nga Awa Purua project, Maori people did not have any ownership of the Joint Venture company at the beginning. These chronological changes show the attitude changes of Maori, from fearing strong control by Mighty River Power to trusting the developer as a partner in a strong relationship.

This change has also benefitted Maori people. For the Nga Awa Purua project, owing to the initial 100% ownership and finance by Mighty River Power, the Tauhara North No. 2 Trust did not have to take any initial high capital and development risks. However, the agreement for the Tauhara North No. 2 Trust to take a share in the Joint Venture at the time of commission secured the rights of landowners, not only cementing the trust between the developer and landowners but also providing a viable business model for local people. By showing its appreciation for property access through such a generous gesture to the landowners, Mighty River Power was well rewarded by the collaboration with the Trust for the Resource Consent process.

6. Lead-time Reduction Efforts

Long lead-times are a general issue for geothermal development. While power generation projects have often completed later than the planned commission dates in New Zealand, there are some good examples of lead-time reduction efforts, too. Both the Kawerau and the Nga Awa Purua geothermal stations are such examples, where the business side efforts made a big difference. Hill and Ware (2010) documented the business efforts made for these two power stations (the efforts made by the developer team mentioned in this section are largely owed to this article).

1) Example 1: Kawerau Power Station



Source of Photograph: Mighty Power River
http://202.74.224.54/Generation/PowerStations/Geothermal/Kawerau/Gallery.aspx
Location: Eastern Bay of Plenty
Commission Date: August 2008
Current Capacity: 100 MW, increased during the commission phase. Original capacity was 90 MW.
Technical Features: Double Flash configuration utilizing high and low-pressure steam inlets with a single stream turbine and generator
Plant Owner/Developer: Mighty River Power
EPC Contractor: Sumitomo Corporation (Japan)
Equipment Subcontractor: Fuji Electric Systems Ltd. (Japan)
Civil Subcontractor: Hawkins Construction (New Zealand)

The Kawerau geothermal station is fully owned by Mighty River Power, but the project enjoyed cooperation with two Maori Trusts and an industrial landowner, Norske Skog Tasman. Norske Skog Tasman is the region's largest electricity user. The negotiations over access to the ground resources involved the Crown, the Ngati Tuwharetoa (Bay of Plenty) Settlement Trust, the Putauaki Trust and Norske Skog Tasman. It was finalized with the Putauaki Trust in 2002, and exploration drilling began in 2003. Mighty River Power purchased the geothermal well rights from the Crown in April 2005. Resource Consent was given to the developer in August 2006 (Mighty River Power 2010a).

The Engineering, Procurement and Construction (EPC) contract was tendered competitively. Sumitomo Corporation of Japan won the contract and subcontracted power generation equipment engineering and procurement to Fuji Electric Systems of Japan and civil engineering works to Hawking Corporation of New Zealand. The construction of the Kawerau Power station began in January 2007 and the plant was commissioned in August 2008, ahead of time and under budget due to the efforts of the team of developers, contractors and subcontractors.

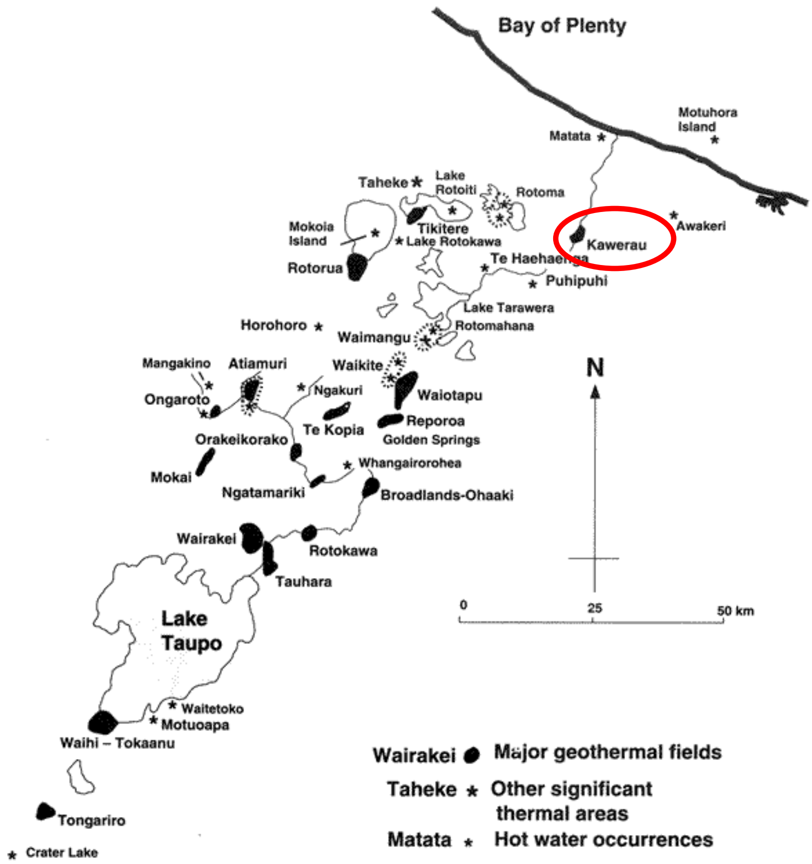

Figure 6-1: Location of Kawerau in the Eastern Bay of Plenty
Source: drawn by the author on NZGA (2012a)

Although a series of measures were taken to reduce construction time, nothing was very new or spectacular. Instead, all involved parties recruited highly capable people and acted in a well-coordinated manner. The key features were the provision of financial incentives, common goals, problem identification and sharing, good planning, an open atmosphere to discussing solutions and continuous coordination among key players.

The initiator was Mighty River Power, which took the approach to value the alliance among all stakeholders, providing opportunities for in-depth discussion and brainstorming between all relevant stakeholders before a contractual stance, engaging in open discussion and debates for optimal solutions to various problems and agendas. In addition, Mighty River Power provided clear messages in the form of financial incentives by offering a scaled bonus for early completion against the original contract's 'taking over' date.

Once Sumitomo was offered the EPC contract and both Fuji Electric Systems and Hawkins Construction were selected as subcontractors, the project agreement was formed among the three. The agreement required all parties (including sub-subcontractors) to coordinate closely and respond to each other in a timely manner. The time difference between Japan and New Zealand was well-utilized. For example, an information request forwarded in late afternoon from one side was responded by the counterpart by the beginning of the next day.

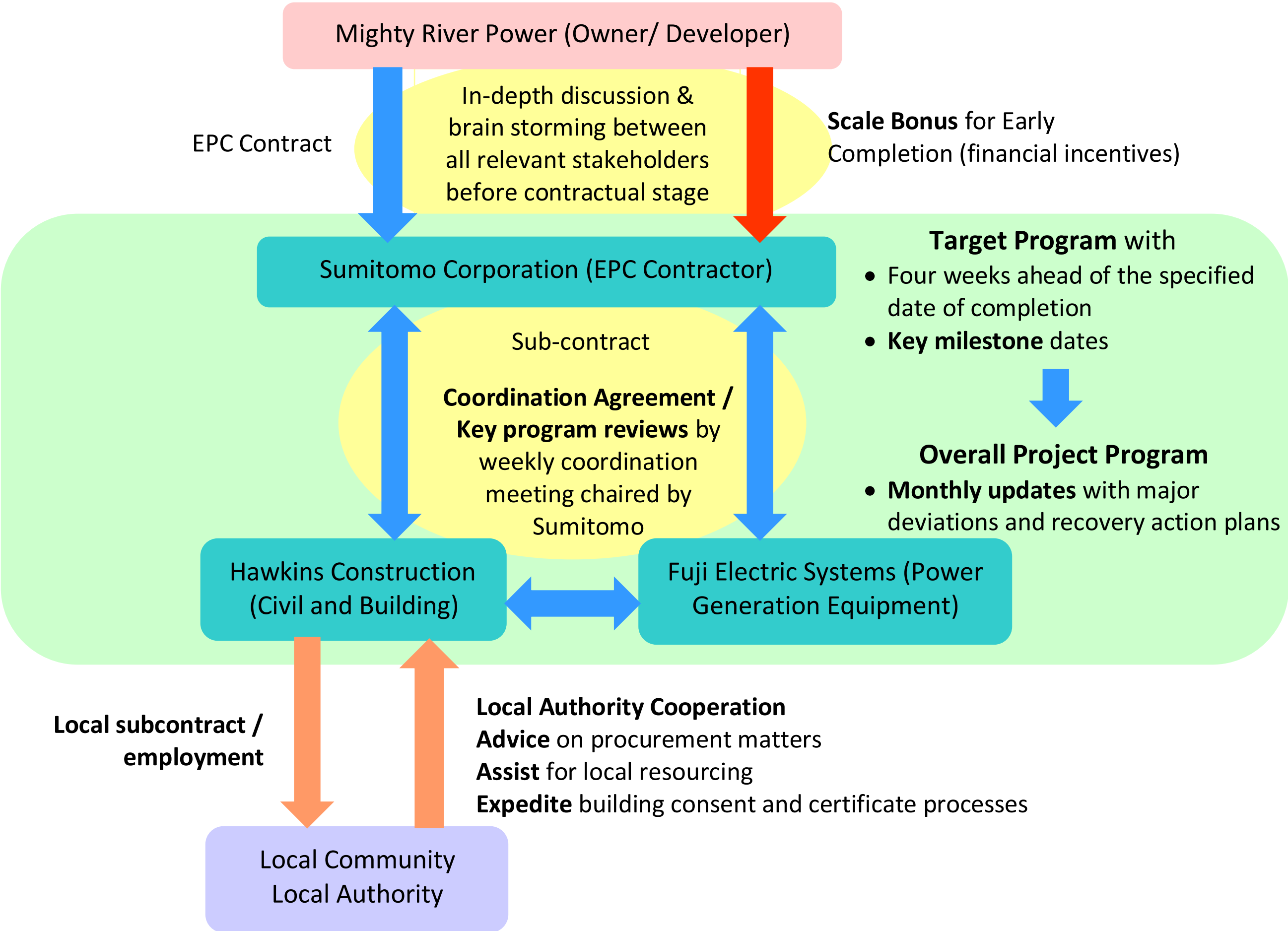

Figure 6-2: Key Features of the Kawerau Alliance
Source: drawn by the author based on Hill and Ware (2010)

The coordination was managed through a Target Program, overall project program and weekly coordination meetings. The Target Program was set by the EPC team (Sumitomo, Fuji Electric and Hawkins) with the aim of plant completion four weeks before the date of completion specified by the EPC contract with Mighty River Power as well as key milestones for the construction process. Then, Fuji Electric created an overall project program based on the Target Program. This overall project program was updated monthly with both major deviations and agreed recovery plans. The EPC team also had weekly coordination meetings to review the key issues in the process, which was chaired by the Sumitomo construction manager. The methods used to solve various problems during the project were also reviewed and challenged in these meetings, and unconventional ways of construction for geothermal plants, such as precast structures and the simultaneous construction of deep structures below the ground and structural frames above the ground, were incorporated. All firms recruited highly capable and experienced technical people, who contributed to the alliance approach.[15]

[15] For example, in the early stage, Mighty River Power designated an Operational Manager of the completed power plant to participate in the planning, engineering and construction phases (Hill and Ware, 2010).

In addition, early efforts to involve all local stakeholders benefitted the process. The Kawerau District Council expedited the building permit and plant operation certification processes to Hawkins Construction, and assisted Hawkins by providing advice on local procurements and resourcing. In return, Hawkins employed a great deal of local people and selected local subcontractors with major industrial project experience, enhancing the well-being of the town. These various efforts made the project commission four weeks earlier than the specified date in the original EPC contract.

2) Example 2: Nga Awa Purua Power Station

The experiences of the Kawerau project greatly boosted the project execution of the Nga Awa Purua project. The same EPC team was chosen by Mighty River Power for the Nga Awa Purua project, which made it possible for all parties to begin early engagement due to the familiarity established in the previous project regarding program planning. The Sumitomo–Fuji–Hawkins team coordinated in designing the concept and streamlining the process. A Target Program was established in a similar manner as before. This time, the target was six weeks before the commission date specified in the EPC contract with Mighty River Power (Mighty River Power, 2010).

Continuous and additional measures were further introduced to enhance the alliance-oriented project execution method established by the Kawerau project. These measures included:

- Development of a matrix review process, which covered all elements of the civil works by Hawkins.
- Mighty River Power engaged Hawkins in the management of the entire geotechnical investigation program, which benefited both parties in understanding the underground risks, transfer of risks between parties and optimal options.
- Hawkins set up a series of 'lessons learned' workshops with sub-subcontractors to study options for pedestal construction. As a result, the Fuji–Hawkins team made structural concept changes for the electrical annex and gas extension, incorporated the increased use of precast, added the use of a post tensioning structure for the cooling tower, and improved pedestal construction sequencing to enhance health and safety.

In addition to these efforts in the construction phase, Mighty River Power advanced the project in multiple fronts before construction began. Figure 6-3 shows the project process from the start of informal negotiations for the establishment of the Nga Awa Purua Joint Venture between Mighty River Power and the Tauhara North No. 2 Trust.

With careful informal negotiations over two years and an intensive two-day workshop after the basic agreement for the new Joint Venture had been created, other business and legal processes went fairly quick, taking only nine months until the beginning of plant construction. This indicates that the understanding of values and alignment of interests between developer and landowners are critical for speedy business execution. In addition, Figure 6-3 demonstrates that once the basic Joint Venture agreement was reached between the two parties, Mighty River Power engaged in drilling, EPC negotiation and the Resource Consent process simultaneously. This reduced the lead-time greatly, as the construction started as soon as Resource Consent was formally obtained.

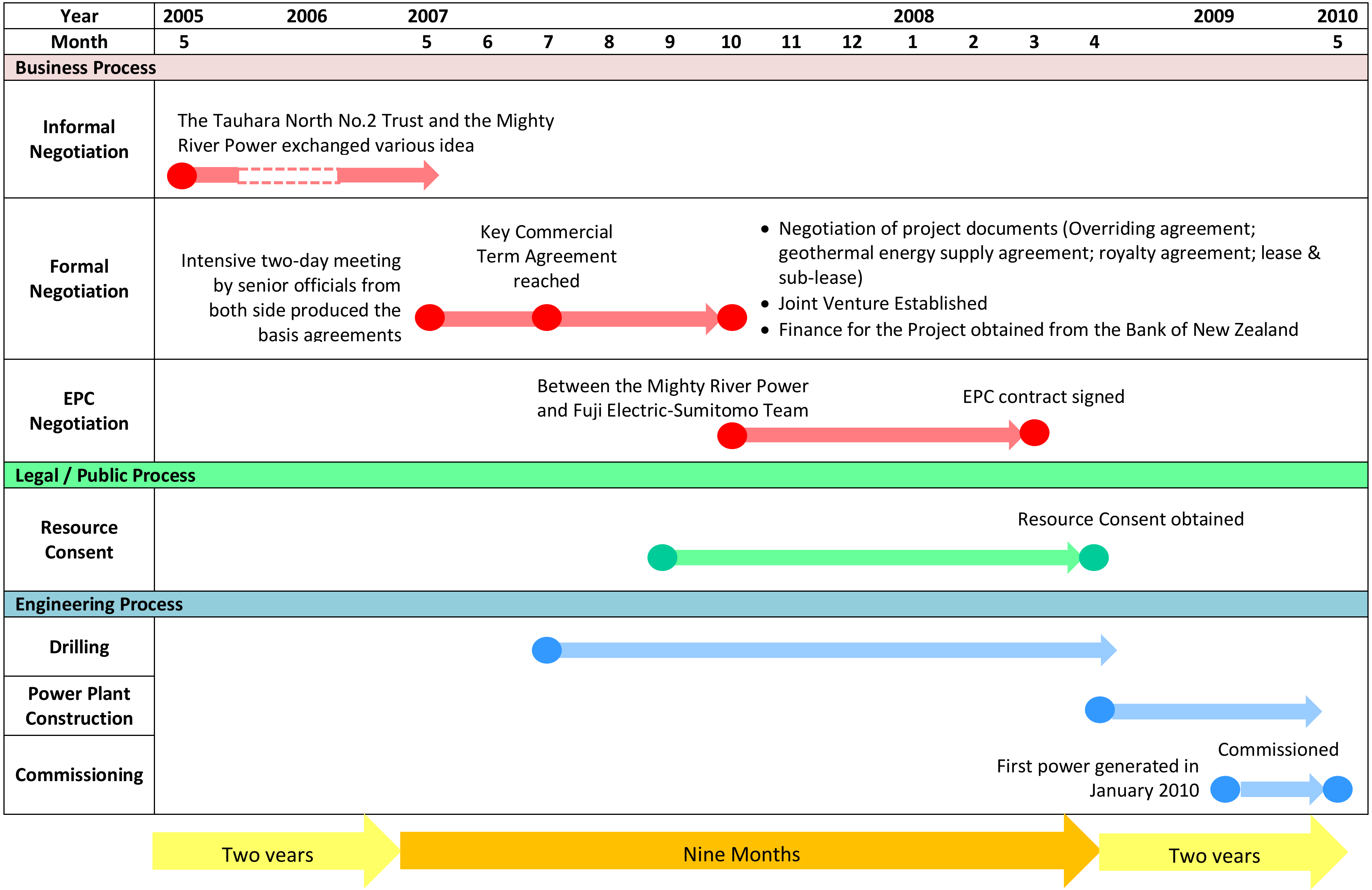

Figure 6-3: Nga Awa Purua Project Process

Source: drawn by the author based on Tauhara North No. 2 Trust (2008)

3) Section Summary

The initiatives taken by Mighty River Power were critical to mobilizing the potentials of contractors and sub-contractors, while good coordination and strong wills by all involved parties were crucial for rapid construction. The financial rewards offered by the developer for early completion were a good motivator, showing the seriousness for the efforts. High capacity of each contractor helped this materialize.

Advancing the project process simultaneously on multiple fronts in business, legal and engineering terms before starting construction was another useful way of shortening the lead-time. This can be only accomplished through clear institutional procedures, which eliminate institutional uncertainties and reduce the risks involved in each process. Creating trust with Maori landowners also enabled rapid project progress.

The experiences of the Kawerau and Nga Awa Purua power stations also provide a lesson on the importance of stable market condition in order to utilize the gained experiences and innovative practices of previous project management to following projects and induce continuous improvements. To utilize the advantages provided by such continuous improvements, efforts to make replicable project execution models and methods on the business side are also required.

7. Market Competitiveness of Geothermal Power Generation in New Zealand

The New Zealand government does not implement either feed-in tariffs or renewable portfolio standards, both of which are common renewable energy deployment policy tools. However, geothermal power generation competes against other technology options very effectively.

1) Renewable Targets

One reason why renewable energy projects such as geothermal power development are happening in New Zealand without these specific financial incentives is the clear Crown policy on renewables. The New Zealand Energy Strategy to 2050 (NZES) released by the Crown in 2007 banned electricity producers from constructing new fossil fuel power plants for the next 10 years. Although this ban was lifted in December 2008 by the new administration, the NZES targets increases in electricity generation from non-polluting and renewable energy sources to 90% in 2025 in order to return the country's CO^2 emissions level to the 1990 level (MOE, 2007; Ministry of Economic Development, 2011b).

In 2010, 74.2% of electricity generation came from renewable energy sources in New Zealand. This number is high compared with other OECD countries. However, the share of renewable energy has actually dropped constantly from 91.4% in 1980 to 64.5% in 2008, as total electricity generation of the country increased and non-renewable energy sources increased their shares. With the 2007 New Zealand Energy Efficiency and Conservation Strategy and recent efforts to increase geothermal and wind, the share of renewable energy has increased in 2009 and 2010. Hydropower has occupied the largest share historically. The country is endowed with abundant renewable resources, which benefit the new energy strategy.

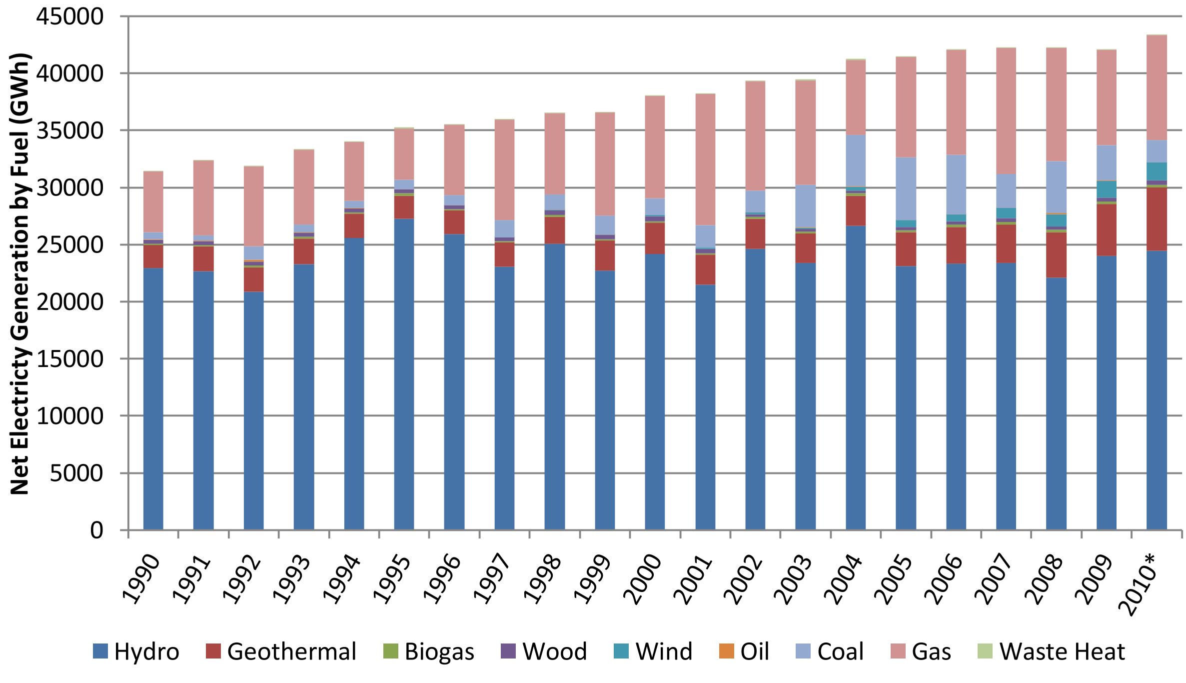

Figure 7-1: Net Electricity Generation by Fuel Type 1990–2010

Notes: The figure for 2010 is provisional. The figures include electricity from co-generation plants.

Data Source: Ministry of Economic Development (2011a)

2) Cost Competitiveness of New Power Plants (at the time of Commission/Market Entry)

The most important reason for the booming renewable energy development in New Zealand is its cost competitiveness against fossil fuel energy sources. The Waikato Regional Council compiled electricity generation costs of various energy sources in 2007 (Denne, 2007). Table 7-1 compares the costs per MWh for conventional (super-critical) coal, combined cycle gas turbine (CCGT), open cycle gas turbine (OCGT/gas peaker), wind, hydro and geothermal plants. These are the costs at the time of plant commission (market entry), which include capital costs, fixed costs and short-term variable costs. As the costs are compared for a unit of electricity generated (cost per MWh), they take efficiency, plant life and load factors into account. The capital costs per unit of electricity generated are also influenced by discount rates, which reflect the cost of capital, while fixed costs, fuel costs and variable O&M costs are not influenced by the cost of capital. Although a 10% discount rate and a 5% discount rate produce different capital costs, the trends are the same.

At a glance, capital costs per kW are highest for hydro and geothermal and more than three times CCGT and four times OCGT. However, by taking efficiency, plant life and load factors into account, the comparison of the capital costs per unit of electricity generated tells a different story; geothermal becomes more competitive than wind, hydro and even OCGT. Furthermore, when adding fuel costs into the calculation, the total costs of all renewable energy options become lower than those of fossil fuel plants. In particular, the combination of the low capital cost and zero fuel cost of the geothermal option make its cost per unit of electricity generated most competitive among all options. As for fossil fuel plants, although the conventional coal option has lower fuel costs compared with gas plants, the total cost per unit of electricity generated is higher than CCGT due to its lower efficiency. OCGT, which has lower efficiency because it is only used for peak load generation, also has both a capital cost and a total cost per unit of electricity generated that are more expensive than CCGT.

The numbers in Table 7-1 are point estimates that do not consider location-specific factors such as site-specific grid connection, infrastructure and the characteristics of geothermal fields as well as factors such as size of project and energy conversion process. Therefore, the same report also checks the cost range for each option, as these factors can change the cost estimates greatly (Figure 7-2). These ranges are estimated by grouping plants of the same energy sources commissioned at various locations. According to this estimate, while the costs per unit of electricity generated of hydro and wind plants vary significantly due to location factors, and can exceed the costs of fossil fuel options in some cases, the costs of geothermal plants have little variation according to location factors, and they are the lowest of the cost ranges for all plant options.

This happens because of the high quality geothermal resources in the Taupo Volcanic Zone where most development occurs. The high temperature and enthalpy resources of the Taupo volcanic fields make double-flash, triple-flash and combined cycle with binary plants possible, increasing plant efficiency greatly. Further, most geothermal plant locations in New Zealand are close to large demand centers with good grid access in North Island, and also located on flat lands with good road access. These reasons make the construction costs of geothermal projects less expensive than those for most hydro and wind projects, which may need to be sited in less construction-friendly locations. In addition, the base-load characteristics such as the high and constant load factors of geothermal contribute to the low variation in total cost per unit of electricity generated. With no fuel costs, geothermal becomes competitive with fossil fuel plants, which can also choose easy locations as necessary and have narrower cost ranges than wind and hydro plants.

Thus, although the comparison of the initial capital cost per kW makes geothermal power generation look uncompetitive, the comparison of total cost per unit of electricity generated changes the picture significantly in New Zealand. Good resource quality, favorable location factors, high load factor and zero fuel costs all make the total cost per unit of electricity generated through geothermal resources the lowest cost power generation option in New Zealand.

Table 7-1: Cost Comparison for Different Types of Electricity Generation Plants in New Zealand (at time of Commission)
Source: Denne, 2007

Plant Type	Efficiency	Plant Life (years)	Load Factor	Capital Cost (NZD / kW)	Capital Cost (NZD/MWh)		Fixed Cost (NZD/MWh)	Fuel Costs (NZD/MWh)	Variable O&M Cost (NZD/MWh)	Total Cost (NZD/MWh)	
					10% Discount Rate	5% Discount Rate				10% Discount Rate	5% Discount Rate
Conventional Coal	38%	25	85%	2170	32.11	20.68	4.16	37.89	3.1	77	66
CCGT	52%	25	90%	940	13.14	8.46	1.78	46.67	3.1	65	60
OCGT	33%	25	20%	720	45.27	29.16	6.85	68.11	3.1	123	107
Wind	--	20	40%	1800	60.34	41.22	8.56	0	7.3	75	56
Hydro	--	25	55%	3000	68.60	44.18	3.11	0	6.3	78	53
Geothermal	15%	25	90%	3000	41.91	27.00	3.81	0	6	52	37

Note: Capital costs are plant construction costs; Fixed costs include the annual costs of labor and some O&M costs; Variable costs are the sum of all marginal costs over all units of electricity output produced (marginal cost = variable cost of the last unit only). Dominated by fuel costs and costs for minor O&M

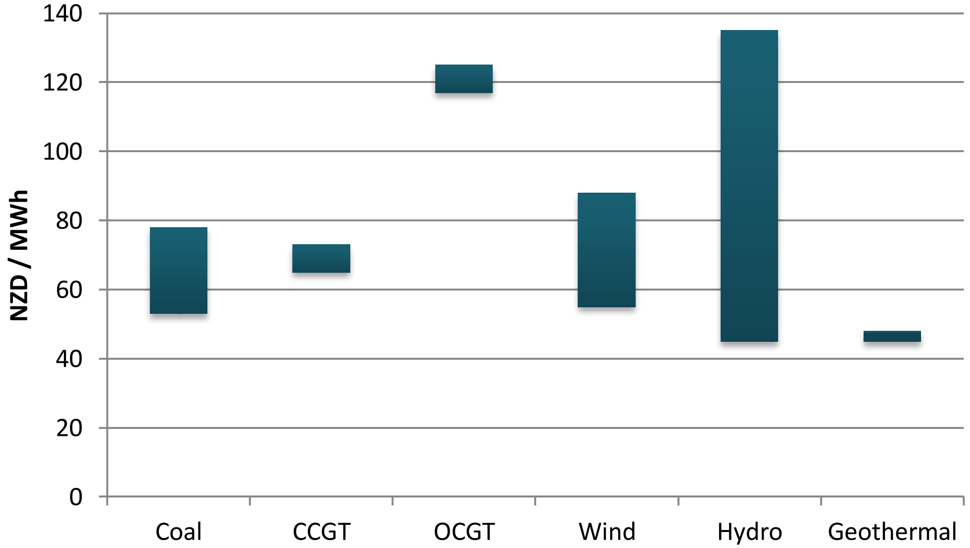

Figure 7-2: Cost Range for Different Types of Electricity Generation Plants in New Zealand (at time of Commission)
Source: Denne (2007)

3) Construction Cost Composition of the Geothermal Development Project in New Zealand

A cost analysis report published by SKM in 2009 estimated geothermal development costs (SKM, 2009).[16] The report estimated the costs for 20 MW and 50 MW greenfield[17] development. These sizes were chosen because of the anticipated difficulty of attracting investment funds for larger-scale development unless the fields are proven with some experience (brownfield) as well as the existence of regulatory requirements for staged development of smaller scale greenfield sites. The capital costs of a geothermal power plant are influenced by a number of factors, including the size of the project, energy conversion process, size and number of individual power generation units and the characteristics of geothermal resources and fields (Mills, 2002, cited in SKM, 2009). In particular, the resource characteristics have a great influence on the size and type of power plant and thus on the capital costs of the plant. The four power plant options considered in the assessment were:

- Single-flash steam Rankine Cycle plant;
- Double-flash steam Rankine Cycle plant;
- Standalone organic Rankine Cycle (ORC) plant; and
- Hybrid steam and binary system plant.

Table 7-2 summarizes the capital costs of the above four types of geothermal plants reported in SKM (2009). It shows that the effects of economics of scale are important for geothermal plant construction costs, as the larger the plant size, the lower the average construction costs are. The same table shows that the deeper the wells, the more expensive are drilling costs. Another important factor is the difference in establishment costs, which include an AEE, land acquisition and obtaining other development permission. As seen in the previous sections, clear institutional frameworks at national and regional levels and continuous efforts to streamline the permit and AEE process have reduced the risks and costs involved in the permit process in New Zealand.

The other important factor is the initial resource survey and research costs. In New Zealand, the extensive historical involvement of the Crown in resource exploration and proof has been said to have reduced development costs (SKM, 2009). In this report, research drilling costs are not included in the estimates, and this makes the establishment costs and costs of drilling low. SKM (2009) suggested that the initial resource exploration drilling carried out by the historical government studies make the exploration drilling costs lower than those in other countries. This is particularly true for the recent and near-future development of Mokai, Poihipi, Rotokawa, Ngawha, Kawerau and Tauhara. If this proportion of drilling costs were to be reduced by half by the national research program in Japan, it would greatly contribute to a reduction in all development costs and risks.

5) Section Summary

In New Zealand, geothermal power generation is one of the most cost competitive options. The government targets of renewable energy to cover 90% of all electricity supply by 2025 and the cost competitiveness make geothermal a natural choice of power generation sources. Although geothermal is not competitive in comparison with construction costs per kW among various options, its total cost per unit of electricity generated is the most competitive due to high temperature resources, high capacity factors and the lack of fuel costs.

[16] The New Zealand Geothermal Association commissioned the assessment of geothermal power generation costs to SKM.

[17] Brownfield in geothermal development means that the geothermal resources have already been sufficiently tested for development. Greenfield represents any untested fields. Geothermal power generation costs are usually assessed on a greenfield basis, i.e. taking account of all costs incurred in the value chain activities of development, from the initial surface exploration, exploration and development drilling and steamfield and power generation plant development to construction and commissioning.

Table 7-2: Estimated Cost Composition of Geothermal Plant by Type (million NZD in 2007)
Data Source: SKM (2009)

	Establishment Costs[18]	**Steamfield Development Costs**	**Plant Costs**	**Grid Connection Costs** (Transformer + 20 km 220 kV line)	**Total Construction Costs (without Drilling Cost)**	**Total Construction Costs per MW (without Drilling Cost)**	**Drilling Costs Per well**
20 MW							
Single Flash (SF)	3.0	15.8	44	2 + 4 = 6	68.8	3.44	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
Double Flash (DF)	3.0	18.7	49	2 + 4 = 6	76.7	3.835	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
Organic Rankine Cycle (ORC)	3.0	15.8	54	2 + 4 = 6	78.8	3.94	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
ORC + steamfield piping	3.0	15.8	67	2 + 4 = 6	91.8	4.59	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
Hybrid Steam & Binary	3.0	15.8	52	2 + 4 = 6	76.8	3.84	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
50 MW							
Single Flash (SF)	3.5	32.5	38	3 + 4 = 7	81.0	1.62	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
Double Flash (DF)	3.5	38.3	42	3 + 4 = 7	90.8	1.816	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
Organic Rankine Cycle (ORC)	3.5	32.5	54	3 + 4 = 7	97.0	1.94	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
ORC+ steamfield piping	3.5	32.5	67	3 + 4 = 7	110.0	2.2	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)
Hybrid Steam & Binary	3.5	32.5	44	3 + 4 = 7	87.0	1.74	3.2 (Production well 1.5 km) 5.2 (Production well 2.5 km) 4.2 (Reinjection well 2.0 km)

[18] Establishment costs include the costs for permits; land acquisition; geo-scientific and environmental; well testing; civil works and infrastructure; site operations; and pre-feasibility and feasibility reports.

8. Lessons learned from New Zealand

1) Risks and Bottlenecks and their Remedies in New Zealand Geothermal Development

The above analysis has shown that New Zealand has developed a unique institutional system and business practices to deal with its inherent technological barriers and risks as well as New Zealand-specific issues to foster geothermal power development over time. Figure 8-1 illustrates a typical geothermal project flow/ value chain in New Zealand and the risks and bottlenecks as well as institutional incentives and business practice remedies to reduce the effects of those risks and bottlenecks.

The largest bottlenecks in New Zealand geothermal development derive from its resource characteristics. The most difficult part is the large footprint required for geothermal power development. In New Zealand, this means the involvement of multiple property owners, in particular on Maori-owned lands. In addition, historical environmental problems in Maori-owned lands caused by geothermal development have created sensitive situations for both developers and Maori. These environmental problems and the necessity to deal with the multiple ownerships of Maori lands have forced developers to work with the Maori community and create interesting business models that benefit Maori in both finance and capacity building, turning this bottleneck into opportunities by creating a win–win situation, thereby overcoming the long and unfortunate history, and providing hope for a better future for all.

The next bottleneck is the high risk characteristics of resource exploration. Navigating through resource surveys, exploratory drilling and geoscience assessments to the development permit stage involves high risks, which remain an important bottleneck in New Zealand geothermal power development. The cost of drilling and availability of drilling rigs for exploration work are other bottlenecks, although these are not a specific problem for New Zealand and not particularly strong (Stephenson, 2012). The resource study developed by the Crown from the 1960s to the 1980s helped developers reduce initial risks and costs.

In terms of resource sustainability bottlenecks, New Zealand's institutional frameworks defined by the RMA 1991 contribute to the reduction of risks of unsustainable development through the creation and implementation of RPSs and Regional Plans and careful environmental and resource assessments during the Resource Consent process. By implementing strategic environmental assessments (SEAs) in RPSs and Regional Plans and clearly classifying geothermal resources into categories with different development potentials, the institutional framework eliminates unnecessary business risks for developers as well as for local residents and the environment (Memon, 2005).

Regarding long lead-times, various efforts have been made to reduce this risk, too. As for institutional mechanisms, the statutory time limits defined by the RMA 1991 for application processing are an important measure to reduce uncertainty. Additionally, the new national Resource Consent process created for projects of national significance in 2009 shortens the Resource Consent process to nine months from the usual one year to two years, which reduces waiting costs and uncertainties tremendously. Lead-time reduction efforts are made in local stakeholder relationship building as well. Good relationship and business model creation benefits developers, as local residents cooperate to reduce Resource Consent processing time and smoothly navigate various institutional and business processes. Business practices also reduce lead-times by simultaneously processing Resource Consent applications and business contract negotiations as well as engaging in fast-track construction practices. Such efficient project execution in New Zealand is considered to be an important contributor for the reduction of initial costs. As a result, Stephenson (2012) noted that lead-time is no longer a bottleneck, as geothermal lead-time is not necessarily longer than those in any other renewable energy projects.

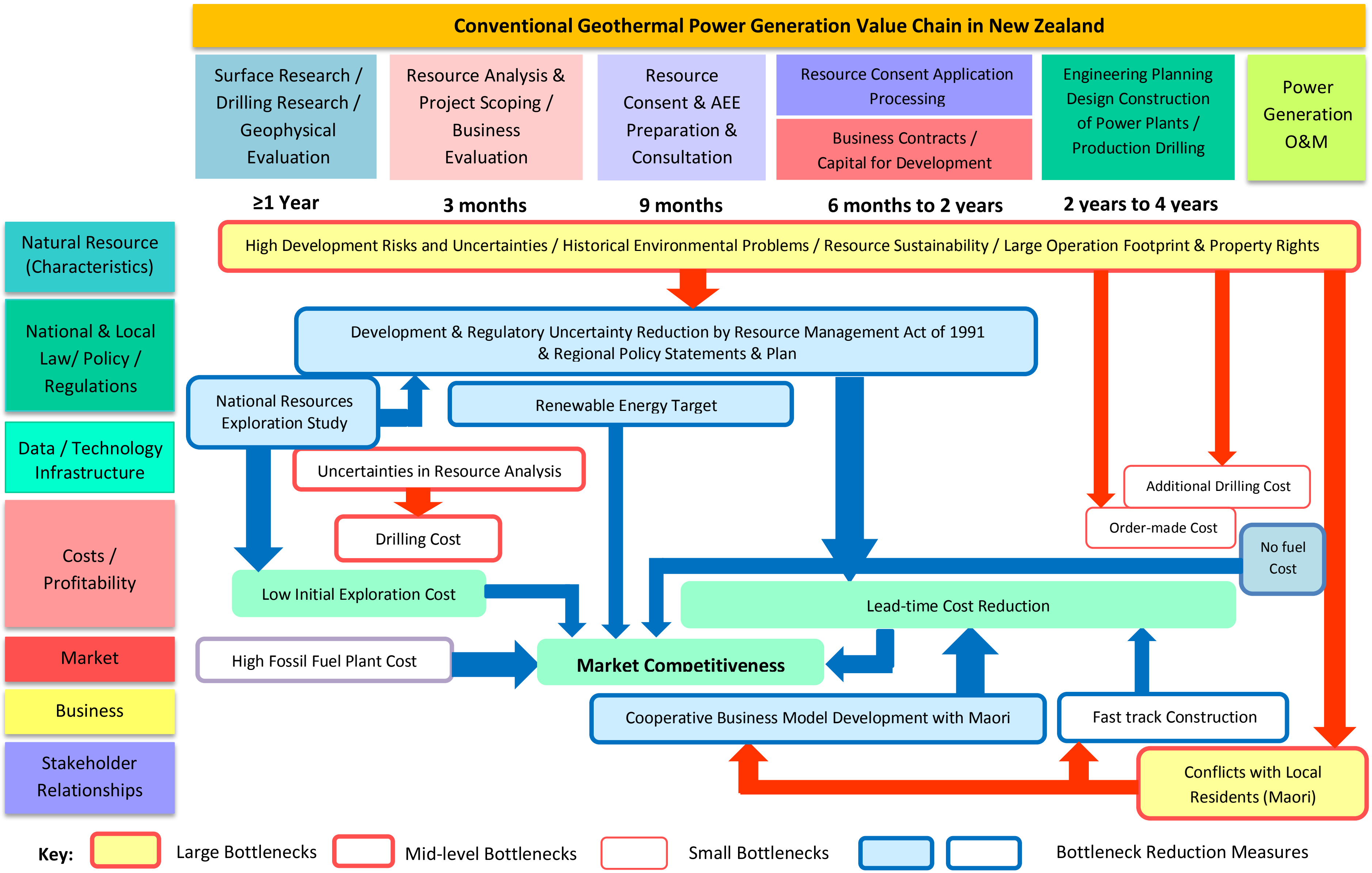

Figure 8-1: Bottlenecks, Remedies, and Incentives of Geothermal Power Development in New Zealand

Note: Conventional means geothermal power which is not micro-generation or EGS systems.

Thus, as Figure 8-1 shows, although there are various risks and bottlenecks, the New Zealand's institutional frameworks and clear regional policies as well as business-side efforts have created remedies for them and turned them into opportunities. Of course, they do not eliminate all bottlenecks and risks. However, it can be said that supportive business environments are in place for geothermal power development. In addition to these efforts, the high cost of fossil fuel power generation makes geothermal power generation an attractive option, creating market competitiveness.

2) Lessons Learned from New Zealand Geothermal Development

The analysis shows several important lessons for Japan. The first and foremost importance is the clear and integrated policy and institutional framework. The second lesson concerns the ways to build fruitful collaborative relationships with the local community. Finally, the last lesson is about cost and lead-time reduction efforts.

Non-piecemeal, Integrated and Streamlined Policy and Institutional Framework

The most important lesson is the significance of a clear policy and institutional framework for reducing the various development risks and uncertainties inherent in geothermal development. In New Zealand, the institutional framework and process are clear for geothermal development. The system also clearly delegates different responsibilities and tasks to different authorities such as Regional and District Councils, the Ministry for the Environment (MfE, including the Environmental Protection Agency and the Board of Inquiry) and the Environmental Court, and provides clear administrative rules for execution. It is important to note that this delegation of responsibilities is vertical from one authority (MfE and its related agencies) at the national level to Regional and District Councils at the municipality level. At the top level, the MfE administers the RMA and oversees all efforts. This framework also aims to balance local and national interests by now allowing for the submission of Resource Consent applications directly to the Crown, while keeping conventional application procedures to local governments intact. Such arrangements make developers only need to deal with a single point of contact (either the Regional and District Council or the MfE) for the Resource Consent process.

Before developers begin to consider geothermal development in a certain location, RPSs and Regional Plans delineate which geothermal fields are for development and which are not. This eliminates a large part of development permit uncertainties from developers and resource exploration time and costs, as projects can be only considered in the fields categorized for development.

The RPSs and Regional Plans that go through SEAs ensure resource sustainability and holistic environmental protection for the region. Hence, individual project AEEs do not have to go through lengthy assessment processes, which otherwise must consider the large-scale regional implications on an ad-hoc basis. The procedure of a project AEE is also clearly defined and specified by the RPS and Regional Plan.

Regional Councils have wide discretion to allow AEEs to be customized as appropriate for the particular development, and the amounts of information to be included in an AEE are determined by the possible environmental effects of a particular development and its scale, although the items are predetermined by RPSs. The high capabilities of municipality staff members make it possible to tailor Resource Consent/AEEs based on various situations and make the execution of an AEE flexible enough to reduce unnecessary burdens for each application, while developer responsibility for the environmental is ensured by the ongoing monitoring and reporting of project performance. It is important that Regional Councils and developers create monitoring systems together to observe the environmental effects caused by the project. Various existing data can be used as background data for an AEE. The knowledge gained from the National Resource Exploration Studies during the 1960s, 1970s and 1980s and the accumulated experiences in various fields have benefitted the creating and adjusting of RPSs and Regional Plans and their flexible application. Overall, the entire institutional system and development permit process is streamlined. The flexible application of RPSs by Councils and the results-oriented approach are effective at encouraging developers to apply the most economical and appropriate methods and technologies at a given point and to adopt an innovative and practical method that considers the different characteristics of each project and geothermal system.

As the Resource Consent procedure defined by the RMA 1991 may not be perfect, there have been adjustments over the years, reflecting lessons from practice. This is crucial for Japan, which does not have a single law for geothermal development or other renewable resource management. This means that the delegation of responsibility is often unclearly spread among different ministries and municipalities and that various regulatory efforts are made on a piecemeal basis. The current Environmental Impact Assessment Act of Japan which obligates quasi-SEA process in each project EIA is quite unusual compared with other countries' EIA systems, and the rigid and lengthy application of EIA without flexibility increases uncertainties and process time and cost for developers. Thus, unlike New Zealand, institutional risks and uncertainties are very high in Japan. The role of the entire institutional system is to create a business-friendly environment by making a simple and clear development permit process, while balancing other interests and needs such as environmental protection and sustainable resource management. Building such a system and human capacity takes a long time. However, as New Zealand engages in such long-term efforts, it is now for Japan to move toward this direction.

Collaborative Relationship Building with the Local Community

The second important lesson from New Zealand is the way of building collaborative relationships with the local community. In New Zealand, many geothermal fields are owned by a large number of Maori people. This makes access to the resources complicated, as developers need to gain access from all land owners. Thus, property rights and landownership are core geothermal development bottlenecks. In addition, historical environmental problems, in particular subsidence caused by geothermal projects in the past, and historical conflicts between the Maori people and European immigrants for the past 200 years have formed a basis of distrust and added complexity to geothermal business risks. To overcome these issues, New Zealand developers have worked on formal and personalized information and data sharing and developed business models that share both the social benefits and the financial rewards of geothermal development with Maori. They provide excellent examples for Japanese geothermal stakeholders to deal with often complicated situations with the hot spring communities near geothermal fields.

One solution for reducing distrust in New Zealand is neutral and technical information and data sharing as well as mutual understanding building with local community members. Bringing third-party, independent technical and scientific experts for environmental evaluations and creating opportunities that allow for polite and detailed explanations to local people are essential for developers. Introducing various overseas geothermal data and practice cases may be beneficial as well.

Another lesson is developing business models with local communities, which provide the direct and tangible benefits of the geothermal power project to them. First, the business models introduced in this analysis show the importance of providing continuous and tangible financial and employment rewards to the local community. Sustained financial rewards always assist local causes and sustainable development. The key is to develop real and continuous businesses together with local people, so that their concerns and intensions are well understood and incorporated into the arrangement, and the rewards are not charity but real business opportunities, payments and/or employment. The New Zealand cases also explain that such business development processes with local people enhance their general business capacity, which can be further utilized for advancing other aspects of their lives.

The New Zealand cases also show that the accumulation of good collaborative business cases will help the further deployment of geothermal projects, even in different communities and regions. The history of the Maori–Mighty River Power Joint Venture shows that Maori people have been comforted little by little, as previous geothermal Joint Venture projects and arrangements have proven to be successful. Japanese geothermal developers must do the same thing to build trust with hot spring communities across Japan. Showing the reciprocal benefits of geothermal development for developers, clean energy users and local communities and accumulating such cases is the only way to solve this difficult issue. The several small-scale binary geothermal plant projects that are currently underway in hot spring areas in Japan may be a good start. In addition, staged development practices in larger projects, which are encouraged in New Zealand, may be useful for Japanese developers to reduce the uncertainty of specific greenfield resources and build incremental trust with local hot spring communities.

For local hot spring communities, it may be useful to build a unified negotiation front such as the Trusts formed by Maori people, as this may clarify the understanding and unification of opinions within the hot spring community and provide strong negotiation power and economies of scale for them as well. The benefits are for developers too, as this creates a simplified point of contact rather than negotiating with multiple stakeholders.

Lead-time and Cost Reduction Efforts
Unlike New Zealand, long lead-times are still a large bottleneck for geothermal power development in Japan. Both institutional and industry-side efforts are important. As mentioned, a streamlined individual AEE/development permit procedure with clear policy direction is essential for lead-time reduction. A local master plan and geothermal zoning/resource classification with SEA such as in New Zealand could also shorten the individual AEE process. Meanwhile, creating AEE processes and items tailored for geothermal projects will definitely help developers provide relevant data and information in a shorter timeframe.

As for resource evaluation, the national government can lead and organize exploration drilling and resource analysis to reduce the financial burdens and risks of developers, as seen in the New Zealand example. Similar national surveys have been done in Japan in the past, but the data has not been centralized nor digitized for wide-spread use. It is also important to accumulate and update more detailed national and regional geothermal resource data for future exploration, local zoning/resource classification and individual EIA project evaluation. For these purposes, a system that gathers the data garnered from not only subsided projects but also all projects that applied for development permits could be created and non-commercial or non-competitive information should be open for public use.

Building industry collaborations is another lesson from New Zealand. The New Zealand fast-track construction example illustrates that coordinated value chain activities and logistics can reduce project lead-times greatly. These examples show that the simultaneous processing of Resource Consent applications, EPC contract negotiations and drilling and other construction/logistics planning are possible in New Zealand, partly because the low institutional risks for development permit and the collaboration system with the local community increase the certainty of development approval. The developer-side initiation of lead-time reduction efforts was the key factors for the success of these examples, too. Fortunately, this particular example involved Japanese firms, and they can bring this experience to upcoming Japanese projects. Japanese geothermal equipment firms and trading firms have been accumulating experience and knowledge from overseas projects even though Japanese geothermal development has been completely halted for more than a decade. Such experiences have helped retain and enhance continuous industry capacity, which will support future domestic projects.

Strong National Principle and Direction
This research also shows that New Zealand has successfully developed a comprehensive social system for supporting geothermal development, which takes care of diverse and often complicated social and natural issues. As the national and local system centered on the RMA is a high quality institutional and policy framework that covers all renewable energy sources, Japan can learn a lot from it to advance not only geothermal energy development but also other renewable deployment.

The center of this framework is a strong respect towards nature, as represented by traditional Maori notions and the strong national principle to develop a national energy future with renewables and build its future as a sustainable society, which is embodied in the RMA 1991 and other energy policies. Japan is falling far behind in this regard. A strong institutional and policy framework cannot be developed without establishing a strong national principle. Japan can learn from New Zealand regarding how to discuss difficult issues inclusively and develop a strong national concept in addition to developing a detailed institutional framework.

Appendix

Information Requirements for Resource Consent Application (including AEE) for Geothermal Power Development in the Waikato Regional Council

Source: Waikato Regional Plan 2008

Chapter 8. Information Requirements

8.1.2. Water and Geothermal

8.1.2.1 Water Takes

a) The location(s) of the take.
b) The purpose for which water is to be taken including the proposed crop/pasture type, reflecting rotational crop requirements.
c) Define the maximum volume of water to be taken as a minimum per day and per year.
d) The rate at which water is to be taken.
e) The source of water.
f) Any associated discharges used to offset the cumulative allocation effects of the taking of water.
g) Identification of alternative water sources including, groundwater, water harvesting and water reuse and provide an assessment of how these may minimise adverse effects, including those on existing and foreseeable future users.
h) Intake screening.
i) The identity and location of other neighbouring abstractors.
j) What effects this activity will have on the environment.
k) The proposed method of recording water use and reporting to Waikato Regional Council.
l) In the case of an application for the replacement of an existing resource consent:
- a demonstrated continued need for the volume and rate of water applied for based on water use records, recognising seasonal and crop rotational factors,
- any enforcement action taken by Council, and
- use of best industry practice.

m) In the case of an application for domestic or municipal supply a water management plan prepared as detailed in method 8.1.2.2 shall be provided with all resource consent applications made in accordance with 3.3.3 Policy 9 and Rules 3.3.4.18, 3.3.4.21, 3.3.4.23, 3.3.4.24 and 3.3.4.26.
n) Details, including distribution extent, of any other properties to which water is to be supplied from this take.
o) In the case of an application for domestic or municipal supply details shall be provided of any existing or proposed riparian fencing and planting necessary to mitigate adverse effects of the take on the water body. Details on proposed riparian fencing and planting shall be provided in the form of a Riparian Vegetation Management Plan having regard to Standard 3.3.4.28

8.1.2.2 Water Management Plans

The Water Management Plan shall establish a long term strategy for the water requirements of domestic or municipal suppliers and their communities. It shall demonstrate that the volume of water required, including any increase over that previously authorised, has been justified and that the water take will be used efficiently and effectively. To this end the water management plan shall, to an extent which is appropriate for the scale of the activity, provide the following information:

1. A description of the water supply system including system operation, distribution extent, levels of service, water use measurement, maintenance and asset management procedures.
2. A comprehensive assessment of existing demand and future demand for water with regard to an assessment of reasonable population growth within the planning horizon to meet the following:
    a) reasonable domestic needs;

b) public health needs in accordance with requirements under any Act of Parliament or regulation;
c) reasonable community needs (e.g. for public amenities);
d) reasonable commercial, rural supply and industrial needs;
e) an assessment as to how each of the assessments required by clauses a) to above is predicted to vary over time;
f) a justification for each of the assessments required by clauses a) to e) above including reference to any relevant planning instruments promulgated under the Resource Management act 1991 that provide for future growth or relevant documents promulgated under the Local Government Act 2002 such as Long Term Plans, growth strategies or spatial plans.

3. Any existing or proposed water pricing procedures and any linkages with wastewater pricing or management.
4. How water reticulation networks are planned and managed to minimise their water losses as far as practicable.
5. A description of patterns of water use practices and/or behaviour in all sectors of use (and distribution) with the objective of maximising water use efficiency and reducing water use, as far as practicable.
6. 6. Water saving targets for the full range of demand conditions including demand saving targets for council owned facilities, domestic demand targets and demand saving targets for commercial and industrial customers.
7. Key performance indicators for each of the water saving targets.
8. Any external auditing and benchmarking procedures that have been adopted.
9. A drought management plan that includes:
    a) steps to be taken to reduce consumption during water shortage conditions, including those uses that will be restricted at the same time as priority SW-B users (in accordance with Policy 18 and Standard 3.3.4.27) and steps to be taken to implement those restrictions.
    b) Targets for the water savings expected to be achieved via the restriction of activities identified in a) above, which shall align as closely as possible to the restrictions for SW-B users provided for in Standard 3.3.4.27. public and commercial user education programmes.
    c) steps taken to reduce consumption when demand is approaching the
    d) maximum take volume specified under the relevant resource consent.
    e) Enforcement procedures

10. Actions, performance measures and a timeline for implementing actions. The actions and performance measures identified will depend on the circumstances of each applicant.
11. 11. Any consultation undertaken with key stakeholders and outcomes of such consultation.
12. Details of an appropriate water conservation and demand management plan review process.
13. Identification of any anticipated increases in water demand over the term of the consent and ability to stage water take volumes to more closely reflect demand requirements over time.
14. Ability to reduce the amount of water used by existing industrial and agricultural users, as a result of improvements in the efficiency of the use of water, in order to meet any increase in water demand over the term of the consent.
15. Identification of any single industrial, commercial or agricultural use of water that uses more than 15 cubic metres of water per day (not being water used for human drinking purposes or human sanitation purposes).
16. Identification of future domestic or municipal supply take needs over and above authorised domestic or municipal supply takes required to meet growth and development that is provided for in planning instruments promulgated under the Resource Management Act 1991 or relevant

documents promulgated under the Local Government Act 2002, such as Long Term Plans, growth strategies or spatial plans (or similar). The projected future needs shall be identified in terms of:

a) Location of take; and
b) Volume of take (including any seasonal variations); and
c) The date at which the water is likely to be required.

8.1.2.3 Transfer of Surface and Groundwater Permits

a) Full names and addresses of transferor and transferee.
b) If the whole permit is not being transferred, the portion of the water permit being transferred.
c) Proposed daily and seasonal (cubic metres per day) and rate (litres per second) of take at new site.
d) Permit number.
e) Location of new take site (show on map or give NZMS 260 map reference).
f) Proposed date/s of transfer.
g) Description of purpose for which water is to be used.
h) Whether the transfer is permanent or temporary and, if temporary, the date on which the transfer ceases.

8.1.2.5 Discharges

a) Purpose for which the consent is sought.
b) Maximum volume of the discharge.
c) The rate at which waste is to be discharged.
d) What treatment the waste will receive prior to discharge.
e) How the volume discharged will be minimised.
f) How the contaminant loading of the discharge will be minimised.
g) What happens to any sludge or solid waste that may be generated.
h) The characteristics of the waste to be discharged.
i) What effect the discharge will have on the receiving environment, including the effect on the purpose of water management classes in Section 3.2.3 of the Plan.
j) The site location and point of discharge.
k) The extent to which the discharge will comply with Policy 1 in Chapter 6.1 of this Plan, with regard to objectionable odour and particulate matter effects.
l) What or whether alternative methods of discharge and treatment have been considered.

8.1.2.9 Drilling

a) Name of drilling contractor.
b) Site and location of bore.
c) Site plan indicating property boundaries.
d) Details of the proposed works including:
   i. bore hole diameter (millimetres)
   ii. bore casing diameter (millimetres)
   iii. bore depth (metres)
   iv. casing depth (metres)
   v. casing materials
   vi. screen materials
   vii. aquifer* (if known).

e) Proposed well yield.
f) Purpose of bore.

8.1.6. Geothermal

a) Project description noting:

i. process intended
ii. reservoir management strategy
iii. production wells
iv. reinjection wells
v. well drilling
vi. well testing
vii. separation plant
viii. steamfield and other pipe work
ix. safety values
x. steam vents
xi. steamfield roading
xii. any steam turbine generating units and other buildings
xiii. cooling towers
xiv. drilling water and domestic water provisions
xv. wash down water and facilities
xvi. sewage disposal
xvii. any hazardous substances used in the well drilling or routine operations of the plant
xviii. contingency planning in the event of emergencies.

b) Management of stormwater.
c) Site access and traffic.
d) Construction related activities including:
    i. earthworks
    ii. construction facilities
    iii. noise
    iv. commissioning
    v. work programme.

e) Description of the environment, including:
    i. extent of the resource
    ii. surface features
    iii. natural heat output
    iv. geology
    v. hydrology
    vi. chemistry
    vii. ecology
    viii. reservoir information
    ix. ambient air quality
    x. ambient noise
    xi. cultural history and historical use
    xii. social/economic environment
    xiii. land use.

f) Description of all activities and emissions requiring consent.
g) Effects and mitigation:
    i. Alternatives considered:
        - location
        - cooling
        - gas and fluid disposal
        - plant
        - water supply.
    ii. Actual and potential effects on:

- geothermal resources
- subsurface effects
- surface thermal activity
- ground water
- surface waters
- subsidence
- seismicity
- ecology
- air quality
- noise
- hazardous substances
- drilling testing of bores
- construction
- tangata whenua
- other uses users of resources.

h) Management and monitoring:

i. Management plan

ii. Monitoring proposals:

- well drilling and testing
- ongoing operations

iii. Proposed contingency plans in the event of effects exceeding acceptable thresholds

iv. Reporting proposals.

i) Results of consultation:

i. Identification of affected and interested parties

ii. Identification of parties consulted

iii. Results of consultation with affected tangata whenua

iv. Results of consultation with other parties

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Please forward the inquiry for this matter to
the Japan Renewable Energy Foundation (Emi Mizuno)
TEL:03-6895-1020 / FAX:03-6895-0121 / e-mail: info@jref.or.jp / URL: http://jref.or.jp