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Managing the Geothermal Exploration Process with Respect to Risk and Regulations

David Sussman, GeoGlobal Energy LLC, 10 4th St., Santa Rosa, CA, USA
Robert Tucker, GeoGlobal Energy LLC, 602 Park Point Drive, Golden, CO, USA
www.GeoGlobalLLC.com

Abstract

Rules and regulations controlling geothermal development differ substantially in the 24 countries currently generating geothermal electric power. Experience with development in various countries shows that regulations that are meant to facilitate development in some cases can actually delay geothermal projects. Since geothermal projects require large initial capital investments, the economics of a project are critically impacted by the time required to advance the project to the point where power is sold to the market. Transparent, consistent laws and regulations are needed for developers, whether private or government, to initiate and complete geothermal developments in an economically reasonable length of time. The actual or perceived levels of exploration and development risk depend on several key factors, including the need for renewable energy, which entities are responsible for exploration expense (private *vs.* government), how frequently the laws regulating geothermal development are changed, the stability of power prices over the life of a project, and country risk.

Existing regulations are routinely revised based on local and international experience, and this is often an important learning process for both developers and regulators. The processes to acquire geothermal concessions and surface access, obtain permission to drill wells and construct a power plant, address environmental and community development issues, and negotiate power purchase agreements are adjusted to fit evolving geothermal technology and local economic, resource ownership and political circumstances. Examples from the USA, New Zealand, Chile and Indonesia illustrate regulations that have encouraged and, in different conditions, discouraged or delayed geothermal development. Although regulatory processes must be adapted to fit local circumstances, experience has shown that some approaches to geothermal regulation are more likely than others to foster geothermal resource development that is both efficient and environmentally responsible.

Introduction

The current worldwide installed geothermal is about 10,000 MW, and most of the nearly 100 operating geothermal fields are associated with young volcanism around the Pacific Ring of Fire and near tectonic plate boundaries (Figure 1). There are many factors that influence geothermal electric developments around the world, including economics, political and cultural issues, and legal regulations. Under ideal conditions, the processes required to bring a geothermal project on-line can take about six years (Figure 2), although this period ranges from as little as 3 to over 40 years (Figure 3). This paper focuses on some of the important regulatory and economic aspects in four countries (the United States, New Zealand, Chile, and Indonesia), and how these have both encouraged and discouraged geothermal developments. For each country, a brief review of the history of geothermal development has been included to provide context.

USA

History

The USA is the leading geothermal energy producer in the world, with a total installed capacity of 2900 MW. The US geothermal industry is mature, and is primarily concentrated in several western states, including California, Nevada, and Utah. Exploration and development activities at The Geysers dry steam field in California started in the late 1950s, and several large liquid-dominated fields discovered in the 1970s and 1980s (e.g., Coso and Salton Sea) were brought on-line by the early-1990s. Geothermal electric installed capacity grew quickly during this time, in large part due to highly attractive power purchase agreements (PPAs) offered by electrical utilities in response to the Public Utility Regulatory Policy Act (PURPA) of 1974, as a result of rapid oil price increases and mandates to support non-oil energy sources.

Currently three major development companies own and operate the three largest geothermal fields (The Geysers, Salton Sea, and Coso), and the combined installed capacity of these fields is 78% of the total installed geothermal capacity in the US. With the exception of the expansion potential of the Salton Sea field, the remaining known but undeveloped conventional geothermal prospects in the US are relatively small (generally <50MW).

US Leasing Process

Geothermal resources underlie federal, state, and privately-owned lands. Both private companies and individuals can obtain the right to develop potential geothermal resources by leasing the geothermal rights from the respective owner of those rights. The geothermal rights related to property in the US are not necessarily owned in conjunction with the surface rights. Below is a brief summary of the leasing process for each.

Federal Leasing

Historically, federal leasing allowed confidential nomination and acquisition of geothermal leases. If more than one application over the same area coincided within a short period, the land was put up for competitive bid. This allowed explorationists to rapidly assess geothermal potential while obtaining security of investment on their exploration investment. After 2005, the federal leasing rules were changed such that all nominated lands are put up for public bid.

The US Government Bureau of Land Management (BLM) now holds periodic lease sales for lands owned by the federal government. Through late 2008 these sales were typically held once each year. Companies and private individuals could anonymously nominate known or suspected geothermal prospect areas for leasing. After the nominated areas are studied by various government agencies (US Forest Service, etc.) to determine that the land is not encumbered by any important environmental, cultural, or social issues, the BLM advertises and holds an open auction for these prospect areas. The leases are awarded to the highest bidder on each parcel. The government does not evaluate the technical or financial ability of the winning bidder to conduct exploration or development on the leased land. As long as the winning bidder can pay the initial bid and continues to make the relatively small payments required to hold the lease, there is no requirement to initiate exploration within the lease period, which generally runs for 5-10 years depending on the state. In 2007 and 2008, BLM lease sales totaled over US$27 million.

With the enactment of the Energy Policy Act of 2005, the time needed to review and award newly nominated and expired geothermal leases has been significantly reduced. In addition, the recently adopted BLM Geothermal Strategic Plan aims to improve the agency's effectiveness and efficiency in processing lease and permit applications. The Energy Policy Act also requires that future forest and resource management plans for areas with high geothermal resource potential consider geothermal leasing and development.

State Leasing

US states have different regulations, agencies and processes to lease state-owned geothermal areas. Lands classified as Known Geothermal Resource Areas (KGRA) based on geoscientific analyses by the U.S. Geologic Survey (USGS) or where lease applications overlap are leased through public auction through either sealed or oral bidding procedures. Leasing of non-KGRA land is usually by competitive bid, although in some states the responsible government agency can award a lease on a non-competitive basis (e.g., the Dept. of Land and Natural Resources in Hawaii and the State Board of Land Commissioners in Idaho). Most states grant a 10-year primary lease term, with the lease then held by production after a power plant has started commercial operation. Annual land rental costs and royalties on production are set by each state.

Private Leasing

Individuals and companies must negotiate directly with the owners of the geothermal rights and any surface landowners, if different. Where there are numerous owners of the subsurface and surface rights over a potential geothermal prospect area, it may take many years for a developer to successfully assemble a sufficient lease position to justify a large and more decisive investment in exploration (e.g., drilling and testing).

Recent leasing and exploration

Since 2007, geothermal leasing activities increased in the US, but actual exploration and development activity may have declined since mid-2008. Reduced exploration activity may be a consequence of the new regulations that put all federal land up for public bid. Several start-up geothermal companies obtained significant geothermal lease positions in Nevada, Utah and California in 2005-2007, but many of these projects are presently stalled. This is likely due in part to the elevated cost of production drilling and drilling materials brought on by the 2005-2008 rise in oil prices and by the shortage of funding following the 2008 financial crisis. Government incentives are likely to significantly increase activity beginning in late-2009.

Incentives for Development

Economic incentives do exist to encourage geothermal development in the US, including individual state requirements that electric utilities purchase a certain percentage of renewable power in date-certain increments, and the recent availability of government assistance and loans by the 'American Assistance and Recovery Act of 2009' (ARRA), also known as the Economic Stimulus Package. The ARRA will be managed by the Department of Energy, allotting US$350 million for new investment in geothermal technologies, which is distributed as follows:

· $140 million for geothermal demonstration projects
· $80 million for enhanced geothermal systems (EGS) technology research and development
· $100 million for innovative exploration techniques
· $30 million for the National Geothermal Data System, Resource Assessment, and Classification System.

The requirement for an electrical utility to purchase power from renewable energy sources is called a Renewable Portfolio Standard (RPS), which is legislated by each state. The RPS mechanism generally places an obligation on electricity supply companies to produce or purchase some fraction of their electricity from renewable energy sources. While Idaho does not currently have an RPS, most of the other western states with significant geothermal resources do, including:

State	Amount	Year
California	33%	2030
Nevada	20%	2015
Utah*	20%	2025
Oregon	25%	2025
Hawaii	20%	2020
New Mexico	20%	2020
Arizona	15%	2025

* Voluntary Goal

Unless contracted along with their power sales, certified renewable energy generators earn renewable energy certificates (RECs) euphemistically referred to as "Green Tags", for every unit of electricity they produce and can sell these along with their electricity to supply companies. Supply companies then pass the certificates to some form of regulatory body to demonstrate their compliance with their regulatory obligations. Because it is a market mandate, the RPS relies almost entirely on the private market for its implementation..

Some states offer additional financial incentives specifically for projects located in their state. The Oregon Department of Energy, for example, offers a Business Energy Tax Credit to those who invest in energy conservation, recycling, renewable energy resources and less-polluting transportation fuels. These tax credits can reach nearly US$7 million in the first year of operation.

Environmental

Geothermal developments still face local land use, environmental, cultural and community concerns similar to those raised by other commercial and industrial projects. Several of the country's largest proposed geothermal developments have faced such concerted local opposition that their schedules and economics have been affected, leaving their future in doubt. This has sensitized project financiers, who scrutinize permitting and environmental issues closely.

Programmatic Environmental Impact Statement

The BLM and the US Forest Service (FS) have prepared a joint Programmatic Environmental Impact Statement (PEIS) to expedite the leasing of BLM-and FS-administered lands with high potential for renewable geothermal resources in 11 Western states and Alaska.

The objectives of the PEIS are to:

1. Assess the direct, indirect, and cumulative effects of leasing, exploration and development of geothermal resources on high priority areas on BLM- and FS-administered lands in order to expedite leasing. Additional environmental documentation is required prior to actual exploration drilling and development.

2. Amend BLM and FS Resource Management and Land Use Plans for geothermal leasing, based on PEIS analysis.

3. Provide analysis in order that site-specific leasing decisions can be made for the pending backlog of geothermal lease applications received by the BLM and FS prior to January 1, 2005.

What works and doesn't work in the US:

1. The national and state leasing processes are clear and transparent. The highest bid wins, and the developer can start exploration immediately.

2. The government recoups its investment in the process through lease payments.

3. The perceived value of alternative energy investment has dramatically increased the price of geothermal leases. This has led to significant amounts of money invested in land. This money is not available to explore the project. Meanwhile, once a developer has been awarded a lease concession, there is no requirement to explore and develop the project for a period of 5-10 years.

4. Resource auctions can have the economic drawback known as the "winner's curse." In some circumstances winners will be those who over-estimate the economic value of a resource. This is particularly characteristic of new resource technologies like geothermal where there is little history to provide a statistical basis for experienced bidders. In this case the most sophisticated developers tend to be less successful in auctions, slowing development.

5. If government is directly supporting an industry or its technology, bidders will typically be more successful with a bidding strategy based on political rather than technical, economic or environmental considerations. In the US, this most commonly consists of speculation on government subsidy and research funding.

6. Several different government agencies are involved in the lease review process. In particular, the environmental review process is sometimes slow, and some Federal lease applications have languished for 8 years or more.

7. Loan guarantees and grants may not significantly speed up a development project since the application and review process still requires months to years to be completed.

Chile

History

Over 300 thermal features ranging from hot springs to superheated fumaroles are concentrated along the axis of the Chilean Andes, mostly associated with Quaternary volcanism. Two shallow wells were drilled in 1921-22 by an Italian group at the best known geothermal area, El Tatio, in the northern Chile altiplano. More systematic geothermal exploration at El Tatio and another northern altiplano prospect, Puchuldiza, occurred between 1968 and 1974 (Lahsen et al., 2005), followed by basic geological, geochemical and volcanological surveys in many geothermal areas of southern Chile. Starting in 1968, 13 exploration wells were drilled by Chilean and New Zealand groups at El Tatio with financial support from the UNDP and the Chilean Development Corporation (CORFO). These wells demonstrated the

presence of a high temperature liquid-dominated geothermal system, but the project was canceled for political and economic reasons in 1976. Six slim holes drilled at Puchuldiza between 1974 and 1976 encountered a moderate temperature (<200°C) resource, and initial feasibility studies for power generation were completed at Puchuldiza and El Tatio (Lahsen, 1976). The results of these studies combined with a country-wide compilation of thermal features (Hauser, 1997) allowed a preliminary assessment of the geothermal potential of the country of >2000 MW of geothermal electric potential (Lahsen et al., 2005).

Between 1995 and 1999, a joint venture between ENAP and Unocal Corp. resumed geothermal exploration in northern Chile, culminating in the discovery of Apacheta, a high temperature geothermal system located between El Tatio and Puchuldiza (Urzua et al., 2002). In Southern Chile, ENAP and CFG (France) conducted geological and geophysical exploration at Chillán. In 1995 they drilled a 274 m deep slim hole that encountered wet steam with a temperature of 198°C (Salgado and Raasch, 2002; Lahsen et al, 2005).

Uncertain natural gas supply from Argentina combined with the vulnerability of hydropower to periodic droughts and the environmental costs associated with new hydropower projects and fossil fuels led to renewed interest in geothermal exploration and the enactment of the Geothermal Law in 2000. In that year, ENAP (the State Oil Company) and Geotermia del Pacifico (GdP, now GGE Chile) re-initiated exploration at El Tatio and Apacheta in northern Chile and conducted geological and geophysical studies at Calabozos in southern Chile. ENAP/GdP exploration activities were abruptly halted in 2002 due to economic issues, and then resumed by a consortium consisting ENAP and ENEL (Italy) in 2005. Exploration activities in Chile continued to expand in 2007-2008, with geologic, geochemical and geophysical studies conducted in at least nine geothermal prospects in northern and southern Chile by four private companies, ENAP, and the University of Chile. In late 2008 through mid-2009, exploration holes were drilled at El Tatio and Apacheta in the north and at Chillán, Calabozos, and Tolhuaca prospects in the south. In April 2009, GGE-Chile drilled a 1073 m-deep corehole at Tolhuaca prospect in southern Chile, discovering and testing a commercial geothermal resource (Melosh et. al, 2009, In Press). GGE Chile applied for an Exploitation License in July 2009, and is planning to construct a power plant by 2012.

Regulations

In Chile all underground resources (oil, gas, minerals, geothermal steam, and water) are owned by the central government, which must grant the right to use or extract them. These are commonly granted independently so, as elsewhere, it is possible for several different parties to have the rights to subsurface water, geothermal resources, and mining resources in the same area. In this case, each of these parties must individually negotiate surface access agreements with the owners of the land. Where two resource rights with different owners overlap (e.g., a geothermal system and a mineral deposit), one of the companies may preemptively apply for the both the mining and geothermal rights in order to prevent competition for surface access.

Leasing Process

The Geothermal Law of 2000 provided the framework for the exploration and development of geothermal energy in Chile and established exploration and exploitation concessions, which are granted by the Ministry of Mines. Exploration concessions are valid for two years and may be extended for an additional two years pending proof of exploration activities. Once commercial production can be demonstrated, an exploitation concession gives the exclusive right to develop the geothermal power

and brines, and to transfer or sell the resource and power plants without any limitation (Lahsen et al, 2005).

To obtain an exploration concession, a developer must submit a formal application to the Ministry of Mines, providing an exploration plan and proposed two-year budget. This information is published in an official government gazette, and if within 45 days no other company requests the same area and no valid objections to development by others are received, the Ministry of Mines will grant the concession to the applicant. This process usually takes about 6-12 months from the date of application, although in practice it can take longer. Once a concession is granted, the developer has the legal right and obligation to begin conducting the proposed exploration activities. If the concession area overlaps with private land, the concession holder must negotiate a formal access agreement with the landowner(s). By law the landowners have the obligation to provide access permits but they have the right to challenge that access in Chilean court. This could delay exploration work in a manner that causes the developer to fail to meet concession obligations and, as a result, lose the concession. Specific environmental permits are not required unless the development is in or near a "special interest area," including indigenous or tribal lands and tourist areas. An Environmental Impact Assessment (EIA) must be approved prior to starting construction of a power plant and steam-gathering system; the EIA process takes between six and eight months.

In early 2008, the Chilean Ministry of Mines initiated a competitive bidding process called a "Licitación." This formal process is invoked when two or more developers apply for all or part of the same geothermal area and requires the bidders to submit a formal application detailing a very specific exploration plan and propose an "economic offer" to pay for that program. One round of Licitación bids was successfully conducted in April 2008. A second Licitación was conducted in March 2009. The Ministry of Mines has not yet announced the concession winner. In June 2009 the Ministry of Mines announced another tender for 20 geothermal exploration concessions (WSJ, 2009) and more are expected at regular intervals.

Although the Chilean government controls subsurface rights for minerals and geothermal energy, there is great sensitivity to indigenous communities, which have objected to some developments for environmental or economic reasons. These issues can usually be worked out through negotiation between the developer and local community leaders, but sometimes unresolved issues are referred to local or national courts.

PPAs and Economic Incentives

The Chilean government has no direct participation in the electrical market. The current basis for the country's power pricing system is that all sources of electrical energy must be competitive, which means that there is currently no special price for non-conventional energy and no special taxes for conventional fuels (e.g., coal and oil). A law passed in 2009 requires that 10% of the country's energy must come from "clean" (renewable) sources by 2014. There is a 30% price penalty on that portion of the generation that falls short of the 10% requirement. Developers can negotiate PPAs directly with private companies, and several large mines in northern Chile that are isolated from the electrical grid have expressed interest in locally generated geothermal electricity.

What works and doesn't work in Chile:

1. The geothermal law and regulations, including access to the power market, are clear and easily managed.

2. The possibility that areas requested for exploration might be subject to competitive bids can reduce the value of conducting reconnaissance exploration to identify prospects since speculators can bid on the same areas without performing any exploration.

3. The publication of areas for competing bids reduces the risk that objections to development will be raised later.

4. The Licitación process requires competition between bidders on an exploration program specified by the government, committing the developer to types of technical surveys or analysis that may not be otherwise performed. This approach can reduce exploration innovation and extend the exploration period.

5. The Licitación process involves bidding the amount of money that will be spent on exploration rather than a fee payment to the government. This avoids increasing exploration risks un-necessarily.

6. The Licitación process favors the highest bidder, not necessarily the party most capable of developing geothermal resources and bringing that power to market.

New Zealand

History

The New Zealand geothermal industry is mature, and all of the operating fields and those currently under development are on the North Island. Geothermal electricity was first developed at the Wairakei field in 1958, followed by Ohaaki in 1989. Both fields are still in operation. As of 2005, the Wairakei field averaged 1250 GWh per year over the last 10 years, for a capacity factor of 93% (Thain & Dunstall, 2005). Ohaaki field had an initial installed capacity of 116 MW, but due to cool water intrusion to the reservoir, the net output had decreased to 30 MW by 2005 (ibid.). New Zealand's geothermal capacity increased rapidly since 2005. Mighty River Power added 135 MW of capacity at the Rotokawa and Kawerau geothermal fields. The current installed geothermal capacity of New Zealand is 584 MW, with another 750 MW of new power plants under development and in advanced planning stages (NZGA, 2009).

Most of the historical development of the New Zealand electricity industry has occurred under direct control of the central government. However, since the mid-1990s the government of New Zealand has converted almost all aspects of the electricity business onto a commercial footing by privatizing large sections of the industry. The most aggressive changes were made in the mid and late 1990s when the generation and retailing of electricity was transformed under Electricity Industry Reform Act 1998. In 1998 the Electricity Corporation of New Zealand (ECNZ), which was responsible for generating 95% of the country's electricity, was divided into four entities. The purpose of the electricity market reform was to reduce ECNZ's dominant position and provide competition in the supply of electricity.

Geothermal Regulations

In New Zealand, all geothermal resources are owned by the central government. The right to develop those resources rests with Regional Councils (similar to county governments in the US) as guided by the Resource Management Act (RMA) of 1991. The RMA changed the focus of environmental planning and management from control of activities (e.g., geothermal exploration, development and operations) to control of the effects of activities on the environment and community.

The government does not require royalty payments from geothermal operations, but instead dictates the terms of the Resource Consents (i.e., the development permits) and takes an active interest in how the project proceeds. Resource Consents can be for no longer than 35 years, but can be renewed. Access to develop a geothermal resource is held by the surface land owner, and the developer must obtain permission to "trespass" under their land. Development rights may be held separately from surface rights, however, and this is the case in a number of fields. In other fields, the projects are joint ventures between the surface rights owner and the developer.

Obtaining a Resource Consent is a time-consuming but generally predictable process, and recent consent processes have taken 6-12 months (Tom Powell, pers. comm.). The developer submits an application to the regional council to develop a project and provides an assessment of the expected environmental effects. Affected parties (this can be anyone affected by the project) may submit questions and concerns on that application. The developer is required to answer these concerns at a public hearing. If the effects are deemed to be minor and all genuinely impacted parties agree not to oppose the project, then a Resource Consent is granted. If all affected parties do not agree with the project, the case is elevated to the Environment Court, where a decision is made. The hearing commissioners have the power to determine if a party is genuinely affected, which helps to keep peripheral advocacy groups from stopping development.

The focus of the RMA is "effects-based" rather than regulatory, so the regional councils have considerable flexibility in writing the "consent conditions" (i.e., the regulations) for the project. For example, if the effects of H_2S emissions are considered to be negligible, there may be no emissions control (as is the case with all NZ projects). Consent conditions remain in effect as written until the consent expires and is requested again. After the original consents expired for the Wairakei field in 2001, the project owner (Contact Energy) applied for new consents to continue operating the plant. This required a large number of consents covering all aspects of operation from well drilling and fluid gathering through air, surface water and ground water discharges. The mitigation or avoidance of adverse effects is a key consideration in the granting of consents and the application and hearing process was the first time the environmental effects of the Wairakei operation have been under public scrutiny since the plant began production in 1958. The process to secure the new resource consents was ultimately decided in the Environment Court and took over six years, during which Contact Energy was allowed to operate the plant (Daysh and Chrisp, 2009).

Leasing Process

Although the government owns the resource, much of rural New Zealand is owned by Maori tribal trusts, which appoint trustees to develop the land to their benefit. This land may not be sold. For geothermal projects on Maori Trust land, the Trust negotiates either a royalty or lease agreement or partial ownership in the project. The success of these projects requires good long-term relationships with Maori communities and leaders, which then act as partners in the resource consent process. Once a project is operating, the developer must act in good faith to maintain the trust of the regional council and the tribal community; after the initial resource consent expires, both are vital partners in the re-consenting process.

Allowances for Renewable Energy

There is no special treatment of geothermal or other renewable energy sources in New Zealand. In late 2007, the New Zealand Government's energy strategy set the target of 90% of New Zealand's total electricity generation coming from renewable sources by 2025, and will not allow the development of additional baseload thermal generation capacity unless required for security of supply (Daysh & Chrisp,

2009). The Government considers new geothermal projects to be of "national significance," and has appointed a Board of Inquiry to review and decide on new consent applications

What works and doesn't work in New Zealand

1. The Community-based Resource Consent Process has delayed geothermal development; however, it also ensures that projects are successful for the entire community and in the long term. This process is partly a result of the New Zealand government's long term successful cooperation with local communities. The time required to obtain consent has also recently decreased partly because all the parties to the agreements are becoming increasingly knowledgeable about geothermal operations. This would be more difficult in a country with resources that are widespread.

2. The RMA process has been characterized by many as a flawed resource development process. More recently Contact Energy has gone to a "call out" where the community hearing portion of the RMA is bypassed and the consent proceeds directly to the Environmental Court for a final decision.

3. All of the geothermal projects have been developed by or in partnership with the electric utilities, indicating the importance of offtake agreements.

4. Recent projects have been developed in cooperation with local indigenous peoples can be a model for other around the world.

Indonesia

Indonesia is commonly believed to have the largest potential for conventional geothermal development in the world, with attractive geothermal manifestations extending nearly 4000 km from the northern end of Sumatra to the eastern end of the Indonesian archipelago. Estimates of the country's geothermal potential range as high as 20,000 MW (Ibrahim et. al., 2005), but only a relatively small percentage of the known and possible resource base has been developed to-date. In the 1990s, the Indonesian government engaged in an aggressive development program through long-term Build-Operate-Transfer (BOT) contracts for the development of combined steam field and power plant projects. The total geothermal power installed capacity increased from about 300 MW to over 750 MW by 1997. There are three privately developed geothermal fields on Java: 377 MW installed at Salak, 260 MW at Darajat (both owned and operated by Chevron) and 220 MW installed at Wayang-Windu (Star Energy/Magma Nusantara). The national oil company Pertamina operates three fields with 200 MW installed at Kamojang on Java, 40 MW at Lahendong in N. Sulawesi and 2 MW at Sibayak in North Sumatra. Geodipa, a Pertamina joint venture with the national power company, PLN, operates 40 MW at Dieng in Java. With five operating fields, two delineated fields at Karaha-Bodas and Patuha, and several drilled prospects, Java is more thoroughly explored than the rest of Indonesia. The delineated fields at Sibayak and Sarulla in North Sumatra are also well explored, and there are several exploration-stage prospects on Flores.

History

In 1974, the Indonesian government decreed that Pertamina should explore and operate geothermal fields in the country. This decree allowed Pertamina to develop the Kamojang dry steam field and to explore other geothermal resources in the country. A second Presidential Decree in 1981 allowed Pertamina to enter into joint ventures with local and international partners. This led to the

endorsement of a Joint Operations Contract (JOC) between Pertamina and Unocal Geothermal of Indonesia Ltd., and an Energy Sales Contract (ESC) with PLN, the State Electric Company for the Gunung Salak contract area in West Java, in 1982. In 1984, Amoseas Indonesia (a subsidiary of Chevron) signed a JOC with Pertamina and an ESC with PLN for the Darajat contract area, also in West Java. Unocal and Amoseas began exploration during the mid-1980s, but neither company commenced plant construction until two additional presidential decrees were signed in 1991. The first decree allowed the Pertamina partnerships to build and operate geothermal power plants, and the second provided economic incentives to accelerate project development. The first 110 MW Salak power plant came on-line in 1994, followed by a 55 MW plant at Darajat later that year. At that time several other companies had obtained concessions and were actively exploring and developing power projects on Java, Bali, and Sumatra. Those projects included: Patuha, Dieng, and Bedugul by Cal Energy affiliates, Wayang Windu by Magma Nusantara, Karaha-Telaga Bodas by Karaha Bodas/Caithness, and Sarulla by Unocal. STAR energy operates Wayang Windu field, which added 110 MW into PLN's grid in 2000, expanding to 220 MW in 2008. An announcement of an expansion to 400 MW in 2006 is not proceeding.

The Asian financial crisis that began in late 1997 caused the Indonesian currency to collapse, and PLN was unable to continue purchasing geothermal power at the contractual rates, which were denominated in US dollars. The Indonesian government took steps to scale back its aggressive geothermal development program by issuing a presidential decree in 1998 (Keppres 5/1998) that resulted in the effective cancellations of essentially all the geothermal projects in advanced exploration stages. These projects included Sarulla and Sibayak in Sumatra, and Dieng, Patuha, Karaha, and the expansions of Darajat and Kamojang in Java. The canceled projects represented a combined total of at least 1745 MW.

Since none of these power contracts contained provisions for significant delays or project/contract cancellations, several years of litigation and international arbitrations ensued. Much of this has been settled but aspects of some geothermal resources remain clouded. Two private developers recovered their investments through political risk insurance policies (OPIC). Despite the awards in international arbitration, the award decision was overturned in Indonesian courts. Although these resource and contract issues have for the most part been resolved, some legal issues may persist 10 years after the fact.

Between 1998 and 2006, the only investment in significant geothermal capacity expansion in Indonesia was by Chevron and Magma Nusantara (later purchased by Star Energy). After renegotiating a new PPA with PLN, Unocal (now Chevron) expanded the Salak field from 330 MW to 376 MW, and Chevron expanded the Darajat field from 110 MW to 275 MW. Magma Nusantara brought Wayang Windu on-line in 2000. Since Star Energy's purchase of foreign-owned Magma Nusantara, Chevron is currently the only foreign geothermal field operator.

Pertamina Geothermal Energy (PGE) is operating four geothermal fields (Kamojang, Sibayak, Lahendong, and Dieng) comprising 312 MW, about one-third of the country's installed geothermal capacity. In 2002, PGE and PLN nominally pooled most of their joint geothermal assets in a new company PT Geo Dipa Energi, and both companies have sought independent investment to help develop geothermal fields in Sumatra. In 2005 PLN, was awarded a Japanese ODA grant to develop 110 MW at Ulubelu (Sumatra), and in June 2009 there were press reports that the World Bank will provide a loan of US$500 million to Pertamina to finance nine geothermal power projects in the country. PGE announced that it would need US$3 billion to build its entire geothermal power projects from the upstream to downstream

sectors. PGE was also seeking loans from the Japan International Cooperation Agency (JICA) and the German bank KfW to finance their projects.

Current Regulations and Implications for Development

Several new geothermal laws and decrees have formed the basis for the evolving system of geothermal stewardship in Indonesia. The geothermal law passed in 2003 set the basic framework for control of resources and distribution of geothermal revenues within the government, with local authorities having the greatest share of both control and income. Geothermal income to the government is to be in the form of income taxes, import duties/levies, and local taxes, with no governmental leasing fees or project overrides. The majority of this income will benefit the regional and provincial governments. Several ministerial decrees in 2007-2008 then established outlines for the implementation of the geothermal law. One of these decrees developed an outline for the process of assigning and overseeing geothermal leases. This process begins with an initial reconnaissance survey of each prospect working area to be carried out either by a private company or by the regional government. Once completed, the results of this initial survey are made publically available, and the working area is tendered by the regional government to the prequalified company that offers the lowest power price for exploration and development. This bid process has one caveat: that the company which conducted the initial survey has the right to match the lowest bidder's power price and thereby win the bid. Project regulation and oversight will then be carried out by regional and central government agencies during the exploration and exploitation phases. While the framework for this system is now in place, many of the details are still being worked out. For example, the terms for company prequalification, the terms and process for negotiating energy sales agreements, and the development of regional government structures capable of regulating geothermal activity are still ongoing. In part because of this ongoing uncertainty, none of the several geothermal tender offers completed to date under this new system has yet resulted in a signed contract or ongoing exploration/development.

Economic Incentive for Geothermal Development

There are no specific PPA or other incentives in the geothermal law or regulations that specifically encourage geothermal development.

The government of Indonesia provides petroleum fuel subsidies, which makes it difficult for geothermal energy to enter the energy market because its price cannot compete with subsidized petroleum fuel prices. Petroleum fuel subsidies lead to a preference for inefficient energy consumption, which has made Indonesia a net oil importing country (Indonesia withdrew from OPEC in 2008). Not only is the geothermal price higher than subsidized petroleum fuel prices, it is also high compared to gas and coal prices. While dwindling fossil fuels and increasing concern with the environmental effects of fossil fuels will raise the prices of these fuels in the long term, incentives must be provided to encourage geothermal development to compete in the subsidized market.

Investment in geothermal development in Indonesia faces substantial uncertainties and continuing challenges. The industry has identified high prices, high capital costs, long payback periods for investment, financing mechanisms, a lack of market opportunities near some of the more attractive prospects, insufficient law and regulation, and regional autonomy as major issues impeding geothermal development (EKONID, 2008). Some foreign investors may still be concerned that power contracts may not be honored over the life of a project unless they are guaranteed by an outside body such as OPIC or the World Bank.

What works and doesn't work in Indonesia:

1. A new, largely transparent system for the management of geothermal projects is being implemented with industry input. The system defines the fiscal environment under which geothermal projects will operate.

2. The system is based on competition among qualified competitors, all of whom should have relatively complete and identical reconnaissance data sets. This should leave competitors on an even playing field in considering bid prices. The competitive parameter is power price, and this should benefit the customer, PLN and the people of Indonesia—if the developer can develop and operate the project at that price.

3. A "lowest bid wins" system for allocating resources gives potential developers an incentive to bid artificially low to capture the resource, with the intent of renegotiating the contract at a later date—a process that has contributed to significant delays in project development.

4. The system is not yet complete, with no methodology yet implemented for consummation of a "bankable" energy sales contract, for example.

5. Allocating control of geothermal assets to regional governments places a large technical and economic burden on those regional organizations in the pre-development years. Their lack of financial and technical resources during those years can be expected to slow the progress of the geothermal projects, and may lead to poorly-supported regulatory decision-making.

6. The system still has non-transparent areas. Specifically, the selection process for the company that conducts an initial survey is not fully transparent. This is especially important considering that this company has the right to effectively circumvent the entire bidding process and claim the working area for itself. This company also controls what exploration data is seen by all other bidders, leaving room for manipulation of the competition.

7. This system requires developers to calculate and commit to a power price long before many of the key resource parameters that influence that price are known. This introduces a large degree of uncertainty into the bidding process, and the result may be inappropriately high or low bids.

Discussion

The examples discussed above for the USA, Chile, New Zealand, and Indonesia suggest the following types of regulations and incentives for leasing, bidding, and other processes to encourage successful and timely geothermal developments:

1. Effective geothermal regulation should include a concession system that is transparent and clear, and that identifies the roles of all parties involved in decision-making. This is generally true for the four countries reviewed although the US system is complex.

2. To eliminate speculation during a competitive bidding process, establish transparent technical and economic criteria to determine which potential leaseholders/developers are capable and serious about development and knowledgeable about resource risk. This should require demonstration of financial capacity to make committed payments, evidence of technical expertise and experience, and a credible exploration plan.

3. In competitive monetary bids, some large fraction of the bid, usually greater than 50%, should be allocated to resource investments. This will encourage a developer to efficiently explore and develop a prospect and will reduce project risk.

4. Provide economic incentives for renewable and geothermal developments that take into account the higher "up-front" investment required to bring these projects on-line. The economic incentives should focus on the early period of plant operations.

5. Streamline the PPA negotiation process for generated power sold to a government-owned utility.

6. At conversion of the lease status from exploration to development, require payment of an annual extension fee equal to some percentage of the development component of a competitive bid, which can alternatively be invested in resource development.

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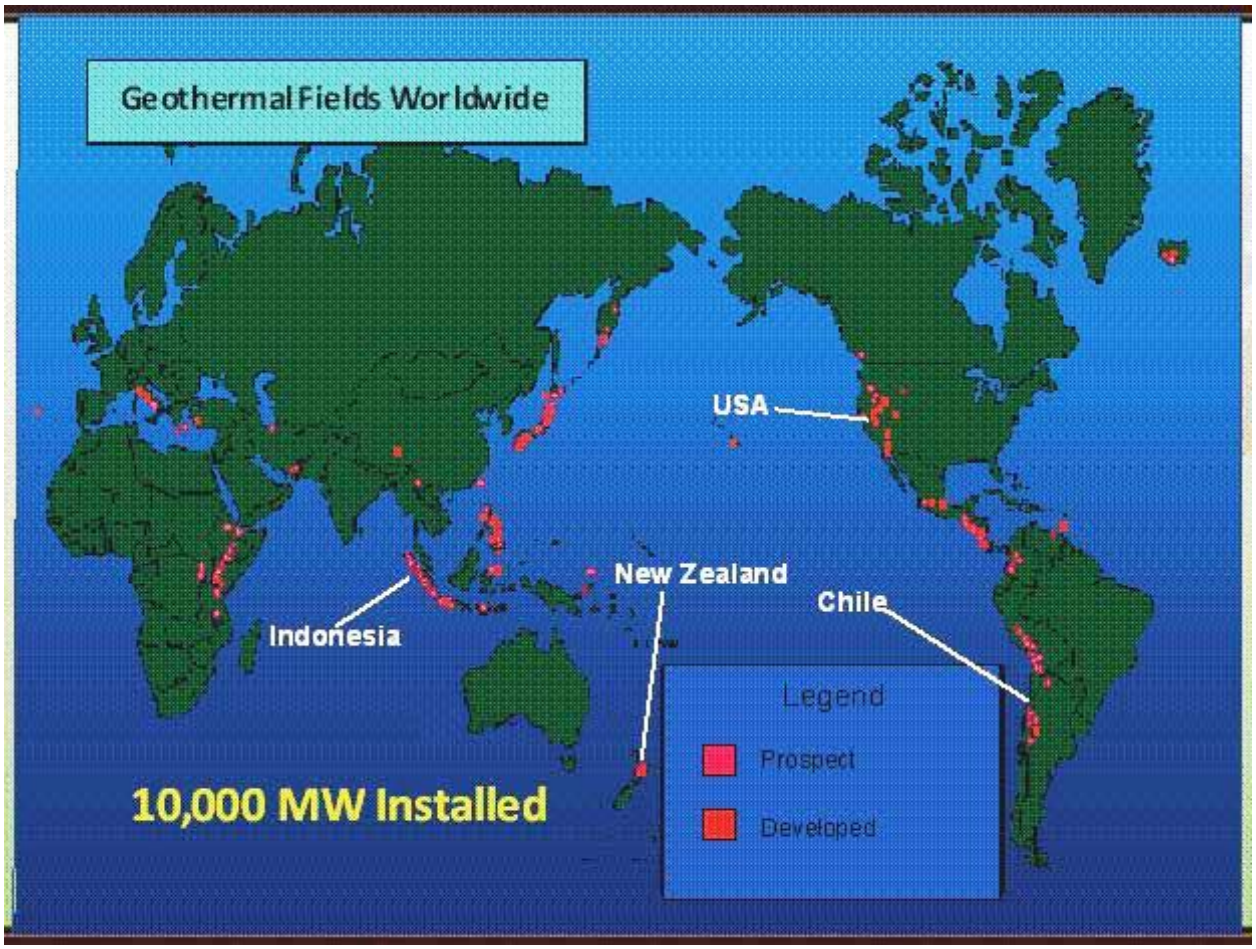

Figure 1. World map showing the locations of operating geothermal fields and prospect areas. The four countries included in this paper are indicated.

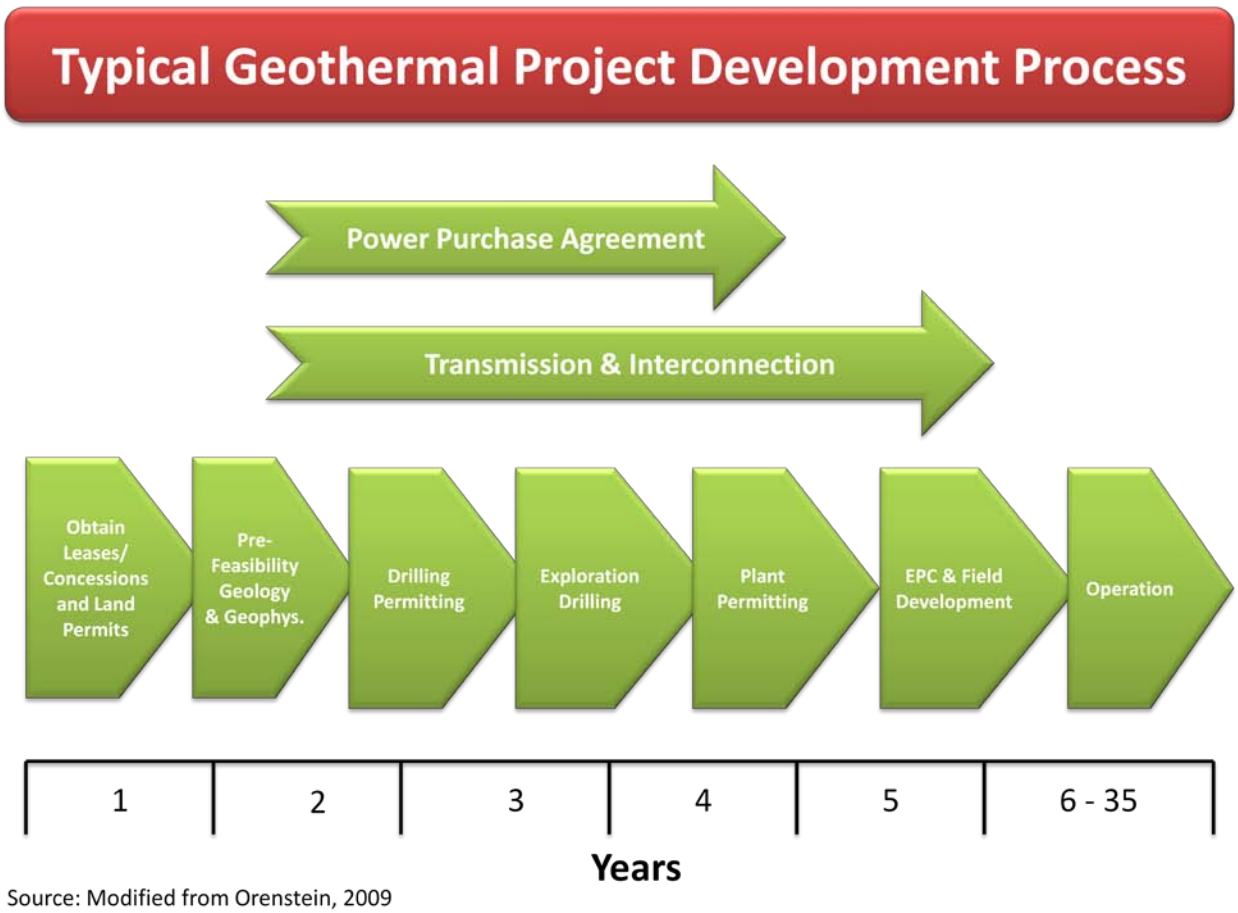

Figure 2. Generalized timeline showing the main activities in a geothermal development, from land acquisition through power plant operations.

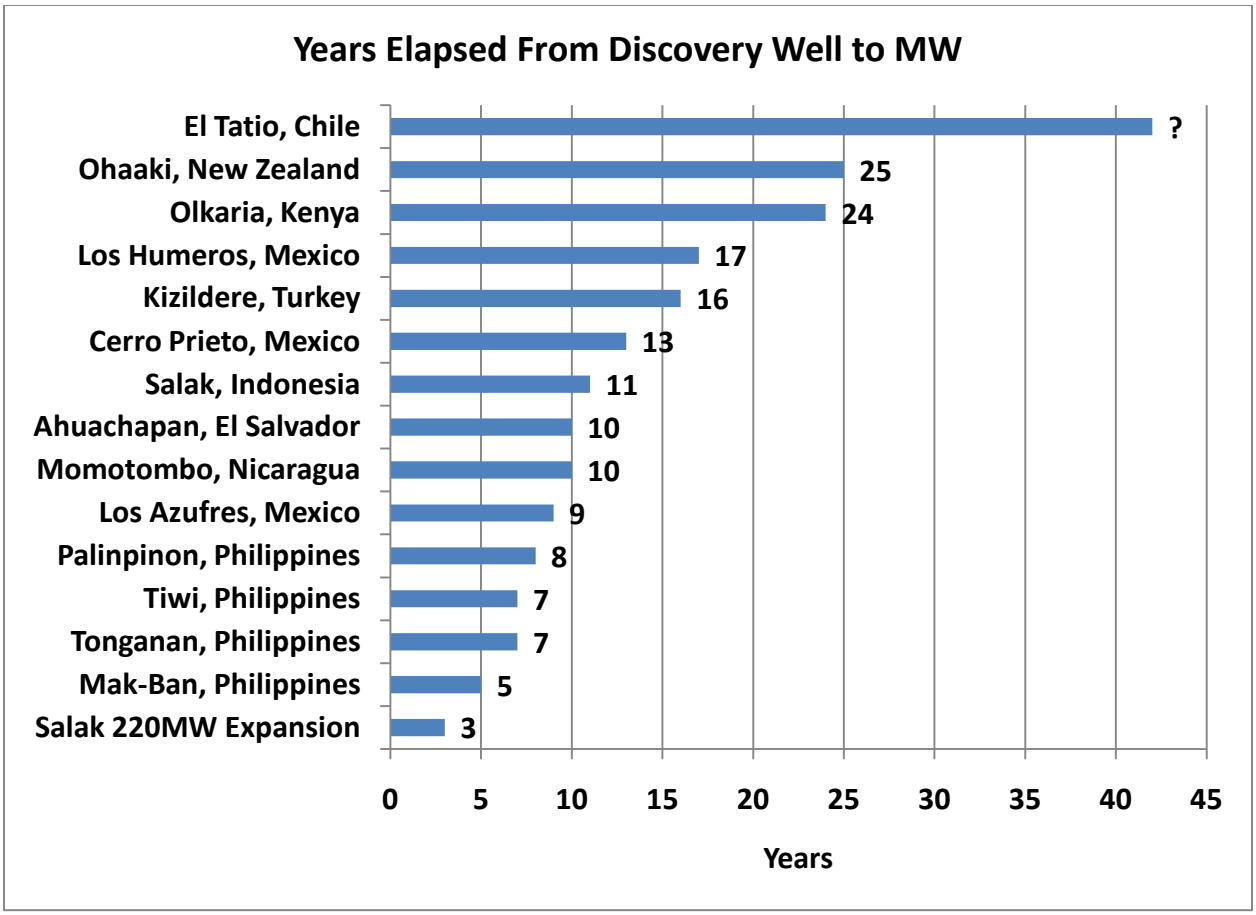

Figure 3. Reducing the elapsed time from the geothermal discovery well (typically the first major project expenditure) to electricity generation is important to the project's NPV. While some delays are caused by a country's economic and political issues, which are beyond the developer's control, many are due to local and national regulations and how they are applied.