Geothermal Exploration Policy Mechanisms: Lessons for the United States from International Applications

Bethany Speer, Ryan Economy, Travis Lowder,
Paul Schwabe, and Scott Regenthal

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List of Acronyms

ADEME	Environment and Energy Management Agency (France)
AIST	Agency of Industrial Science and Technology (Japan)
DOE	U.S. Department of Energy
FIPP	Financial Institution Partnership Program
GEA	Geothermal Energy Association
GFF	Geothermal Fund Facility
GW	gigawatts (electric)
ITC	investment tax credit
KfW	Kreditanstalt für Wiederaufbau Bankengruppe of Germany
MOL	Hungarian Oil and Gas Company
MW	megawatts (electric)
NEDO	New Energy Development Organization (Japan)
PTC	production tax credit
USGS	United States Geological Survey

Executive Summary

According to a U.S. Geological Survey (USGS) estimate, the United States has nearly 40 gigawatts (GW) of power generation potential from identified and unidentified conventional geothermal resources (Williams et al. 2008a).[1] To realize these resources, geothermal project developers must overcome several obstacles that are unique among the renewable energy technologies. One significant barrier in geothermal project development is the high investment risk during the resource exploration phase, which can make financing a geothermal project difficult as compared to other renewable energy sources, including wind and solar (Salmon et al. 2011).

Many federal and state policies provide incentives to renewable energy sources, including geothermal; however, these policies rarely differentiate between the technologies, with the common exception of the level of remuneration provided (e.g., the amount of a rebate or tax credit). These incentives, therefore, may not adequately address the more nuanced support required to advance geothermal technologies (Doris et al. 2009). For example, at present many geothermal policies support the operational phase of the project, but much of the risk is in the development phase. If policy-makers wish to incentivize development of geothermal power capacity, policies may need to address exploration risks specifically, thereby improving developers' access to financing through this vital stage in the development cycle.

A number of governments (both in the United States and abroad) and international development organizations have supported exploration and confirmation of conventional hydrothermal geothermal resources with a variety of public policies. In order to define the scope of this analysis and provide conceptual clarity, this report focuses on the five general policy types listed below, as well as hybrid combinations that have been applied to geothermal and are understood to have the potential to support geothermal power in the United States, specifically (see Table ES-1):

1. Loan guarantees
2. Drilling failure insurance
3. Lending support mechanisms
4. Grants
5. Government-led exploration.

The analysis describes each policy type applicable to the exploration drilling phase and presents examples of their use in a variety of countries and regions. It also assesses each policy's potential applicability to the U.S. geothermal market. The report is intended to offer a review of select past and current policy applications to policymakers, providing a basis for evaluating options for future geothermal exploration policies.

[1] This number is the combined mean estimate of identified and unidentified geothermal resources.

Table ES-1. Policy Descriptions, Examples, Summary of Characteristics, and Potential Applicability to the United States

Policy Description	Examples	Characteristics[a]	Potential Applicability to the U.S. Market
Loan Guarantee: As a third party to the transaction, a government agency or other public entity provides a guarantee of debt repayment to a lender in the event of borrower default. A fee is often required of the developer.	United States; Germany	Loan guarantees can provide high leverage of private investment in case of low payouts but have thus far demonstrated limited results in the U.S. geothermal market.	The Section 1705 Loan Program within the U.S. Department of Energy (DOE) provided $545.5 million in guarantees to five geothermal projects, although similar programs for renewable energy projects may be unlikely due to the political environment following bankruptcies of a few loan guarantee recipients; however, these guarantees were provided to manufacturers and not generators. Designing loan guarantees to cover loans provided specifically for the exploration phase could spur more debt financing at a phase primarily funded with more expensive equity.
Drilling Failure Insurance: The developer pays a premium to access a government-provided partial-cost reimbursement. The reimbursement is paid in the event that the exploration phase does not result in a predetermined level of success for a given project.	France; Multilateral banks and development agencies	Drilling failure insurance can provide high leverage of private investment when the number of claims is limited. Premiums may be cost-prohibitive for developers, and there is the potential for large public funding expenditures depending on the total value of the claims paid.	Policymakers could offer drilling failure insurance as an alternative to loan guarantees or lending support mechanisms to reduce the cost of financing. An insurance program would require a significant up-front allocation of funds to capitalize the insurance pool.
Lending Support Mechanisms: A government entity reduces the cost of the loan by buying down the interest rate, providing for a longer loan term, paying a portion of the interest, or offering some other loan support.	Germany	In instances when the terms required by lenders may be prohibitive for the developer, government interest rate support could make loan terms more amenable (p. 37). Government-supported loans (e.g., direct loans or public-private partnerships) could successfully leverage private investment at subsequent stages of development but may crowd out private investment in the exploration phase.	An interest rate subsidy provided by the government to a private lender could be less costly to the government than outright direct loans, but such a program would still require significant public investment. Public investment would also be unrecoverable unless developers are required to pay back the interest subsidy once the resource is proven.

Grants and Cooperative Agreements (Grants): A government entity or other institution offers cost-sharing schemes or other forms of direct payments intended to reduce the investment cost during the exploration phase.	United States; France; Multilateral banks and development agencies; Australia; Iceland; Japan	Grants and cooperative agreements can be effective for individual project development, but depending on the amount of support provided, they may result in limited leverage of private investment during the exploration phase, leading to significant public funding commitments.	Grants and cooperative agreements successfully spurred initial growth of geothermal projects in the United States but may be limited in their ability to significantly impact overall market development today due to the low leverage of private investment and higher funding requirements.
Government-Led Exploration: A government entity undertakes exploration activities directly or contracts private firms to do so on their behalf. Proven resources are developed by government-owned enterprises or auctioned to private firms.	Iceland; Japan; New Zealand; Indonesia	Shown to be effective for project development in markets where little to no exploration activity is occurring. However, government-led exploration provides lowest leverage of private investment and highest level of public investment.	Despite historical federal support of geothermal exploration, this policy may not be well suited to the United States at present. This is because it is not market oriented and because of the perception that the geothermal market is more mature than it was when first spurred in part by the government in the 1970s and 1980s.

[a] The organizing principle of this section is "leverage" or the level to which a policy can incentivize private investment with public funds The assessments of leverage provided within the characteristics column are general comparisons across the five policy types. Actual leverage will depend on the specifics of a policy's design.

The key takeaways from this analysis include:

- **If policymakers want to encourage more geothermal exploration, they could consider policies that initiate lending to early stage projects.** Nearly all U.S. projects are funded by equity during the exploration phase. Encouraging more lending during the exploration phase would provide another form of capital in the form of debt and could be done via loan guarantees, government direct loans, or a combination of both. The advantage of accessing greater proportions of debt is that this could help lower a project's weighted cost of capital due to the typically lower cost of borrowing funds as compared to gaining equity investors. Encouraging lenders to participate in the exploration phase or providing loans directly via a "Green Bank" or a program similar to the Loans for Geothermal Reservoir Confirmation program could help reduce the cost of capital and increase the volume of funding available at the exploration phase.
- **There are policy options that help encourage additional equity investment during the exploration phase.** For example, re-authorizing a cost-share grant program, such as those utilized in the United States in the 1970s and 1980s, could help developers limit the risk to investors during the exploration phase.
- **Geothermal-specific policy innovations can account for unique project development characteristics.** One possibility could be tax incentives for exploration-phase drilling. Exploration-drilling tax incentives—either in the form of credits or deductions—could decrease geothermal development companies' tax expenses during the exploration phase, offsetting some of the financial risk incurred during the exploration phase. Other policy options include incentives to encourage the assessment or utilization of geothermal fluids co-produced from oil and gas exploration, which could help expand the resource base.
- **Some geothermal incentive policies do not fit neatly into clearly defined categories.** Several countries and multilateral agencies have implemented or are developing support mechanisms that overlap the five conceptual policies summarized above. Exploration policies can be creatively designed and can be a hybrid of the five general policies types described in this report. Examples of this include the loan/cost-share drilling program in Japan, the Risk of Non-Discovery of Deep Geothermal Energy loan program in Germany, and the Geothermal Fund Facility in Indonesia.

Table of Contents

List of Figures

List of Tables

1 Introduction

The U.S. geothermal market is the largest in the world, with an installed capacity of 3,386 megawatts (MW) as of February 2013 (GEA 2013). However, the pace of new utility-scale geothermal electric projects coming online in the United States has been slow over the last two decades. Even considering the most recent period of robust government investment for renewables following passage of the American Recovery and Reinvestment Act of 2009 (Recovery Act), the U.S. market has only grown about 14% in the decade preceding 2012 (EERE 2012).

Despite providing reliable baseload power and being a commercially viable technology, conventional hydrothermal generation projects face several key challenges to development:

- A general lack of investors familiar with the technology and appropriate deal structures (Salmon et al. 2011)
- Long lead times between project conception and completion (typically four to five years)
- Remote locations of project sites, potentially requiring expensive build-outs of transmission capacity that add to project timelines and costs (Hurlbut 2012)
- Competition for capital and equipment with other extraction industries, including the coal and oil and gas industries (Salmon et al. 2011)
- High risks and subsequent costs of capital during exploration drilling.

In this report, we focus on the last barrier because the high risks and cost of capital associated with the exploration phases is a key challenge to geothermal plant development (Salmon et al. 2011). Failure to confirm the geothermal resource during the exploration phase results in a forfeiture of invested capital. This risk might drive investors away from geothermal financing, especially those lenders who have risk appetites that are typically lower than that of equity investors.[2] Further, those investors are likely to require higher yields to compensate for the risk as compared to other stages of geothermal plant development.

The primary difference between developing a geothermal project compared to other renewable energy technologies lies in the challenges of identifying and confirming the resource (Salmon et al. 2011). With geothermal projects, the resources must be identified and confirmed on a site-specific basis whereas with other technologies, such as wind and solar, the initial identification can be done on a regional basis (although further assessment of local resources may be necessary, especially with utility-scale projects). However, current renewable energy policy in the United States does not address geothermal exploration risks specifically (i.e., the production tax credit). In addition, current renewable energy policies provide operational incentives, which do not directly support these pre-operational and yet vital—and costly—phases of geothermal power plant development.

This analysis focuses on policy options that could potentially fill this gap by providing geothermal developers with pre-operational incentives to target the initial, high-risk project

[2] In the United States, debt financing is rarely used for this phase of development (Salmon et al. 2011).

development phases. It builds on the following geothermal policy analyses by referencing relevant research where pertinent, while avoiding repetition of the previously conducted work: Speer (2012), Rickerson et al. (2012), Salmon et al. (2011), and Doris et al. (2009).

1.1 Background

The risk profile for geothermal projects is unlike other renewable energy technologies, such as wind and solar, that can quantify their resources through comparatively inexpensive site assessments and accessible weather data. In contrast, geothermal projects can only verify the existence and quality of the resource through exploration drilling, which is expensive and may not result in a feasible project or one that produces as much power as originally estimated. Although the International Finance Corporation estimates that 59% of wells drilled during the exploration phase have been successful globally, the rate in the United States for well-researched and vetted sites may be in the range 35%–50% when economic and other factors are taken into consideration (IFC 2013; Speer 2012).[3]

It is also possible to leverage oil and gas drilling results to help identify geothermal resources. Some oil and gas projects may also be viable for geothermal co-production; however, co-production projects are currently in the demonstration phase and may have more limited applications due to their remote locations and smaller capacity as compared to utility-scale hydrothermal plants. At the time of writing, ElectraTherm had commissioned the only co-production geothermal power plant in the United States (GEA 2013).

There is no singular definition of the phases for developing geothermal projects. For the purposes of this report, we chose to use the Geothermal Energy Association's (GEA) description of the phases, which are outlined in Figure 1 (GEA 2010a). This report focuses on the first and second phases, which are collectively referred to herein as "exploration."

[3] The IFC (2013) defined successful wells as those with a potential of 3 MWe or greater, regardless of the potential return on investment of building a power plant at the site. Wells with a potential less than 3 MWe were also considered successful if connected to a currently operating power plant.

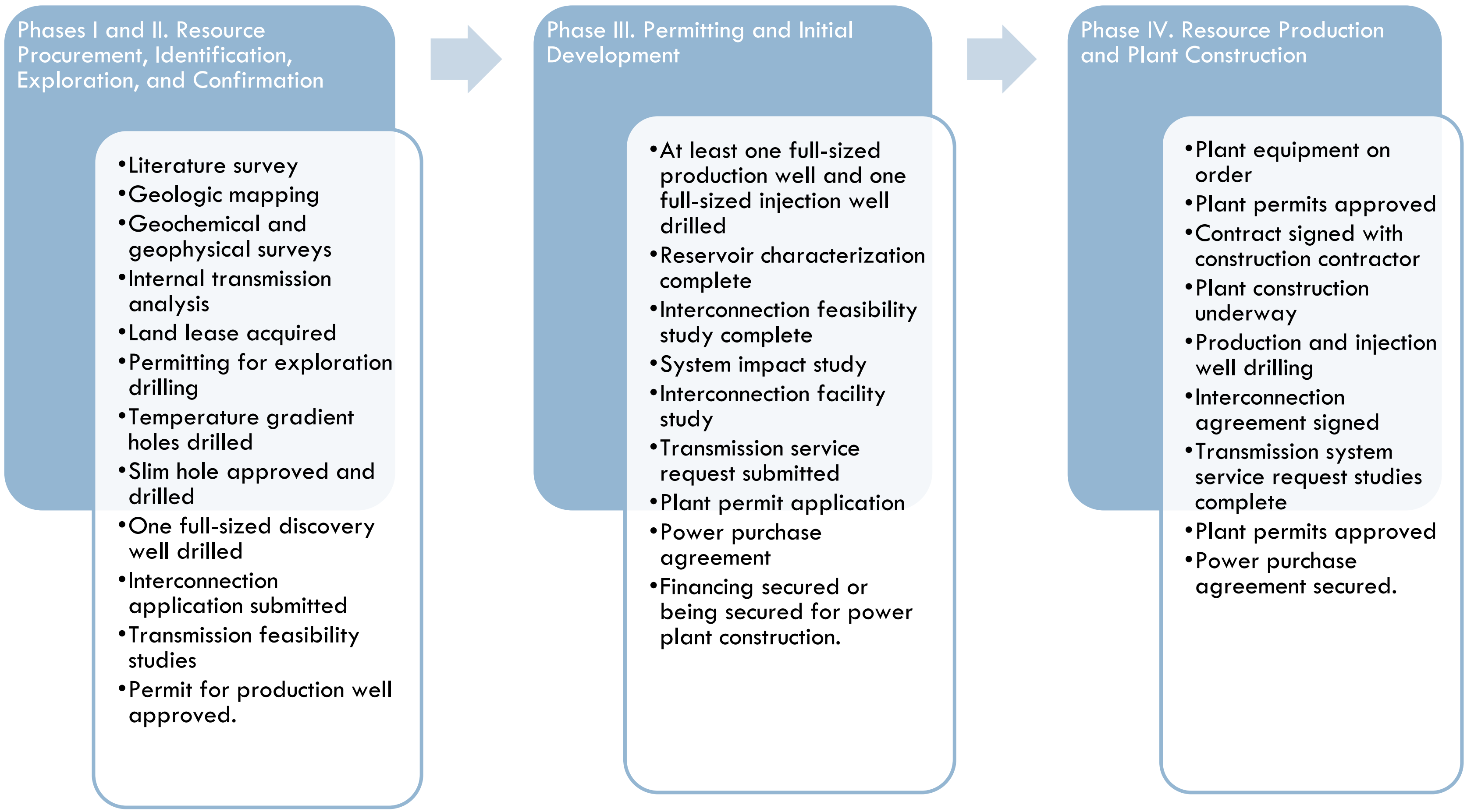

Figure 1. U.S. Geothermal Energy Association's terms and definitions for geothermal resource development (2010a)

The outcome of Phases I and II determines the future of the project. The full range of activities required to confirm a potential geothermal resource, including drilling a single full-sized discovery well to determine the presence and quality of the geothermal resource, can cost $6 million to $10 million (Project Finance 2010). The probability that the well will be dry or partially dry (i.e., the temperature and flow-rate are too low to meet generation targets) is considerable (Salmon et al. 2011). If the resource cannot be proven or it is otherwise insufficient for the project's needs, the project must be abandoned and investor capital is lost.

The challenges of the exploration phases are exemplified by the consistently larger number of projects in Phases I and II starting in 2010 compared to the number of projects in later phases of development (e.g., Phase III and beyond) (see Figure 2.) This backlog of projects could be due in part to the exploration risk and subsequent financing challenges that may be preventing the projects reaching the next stage of development (NREL analysis; GEA 2013).

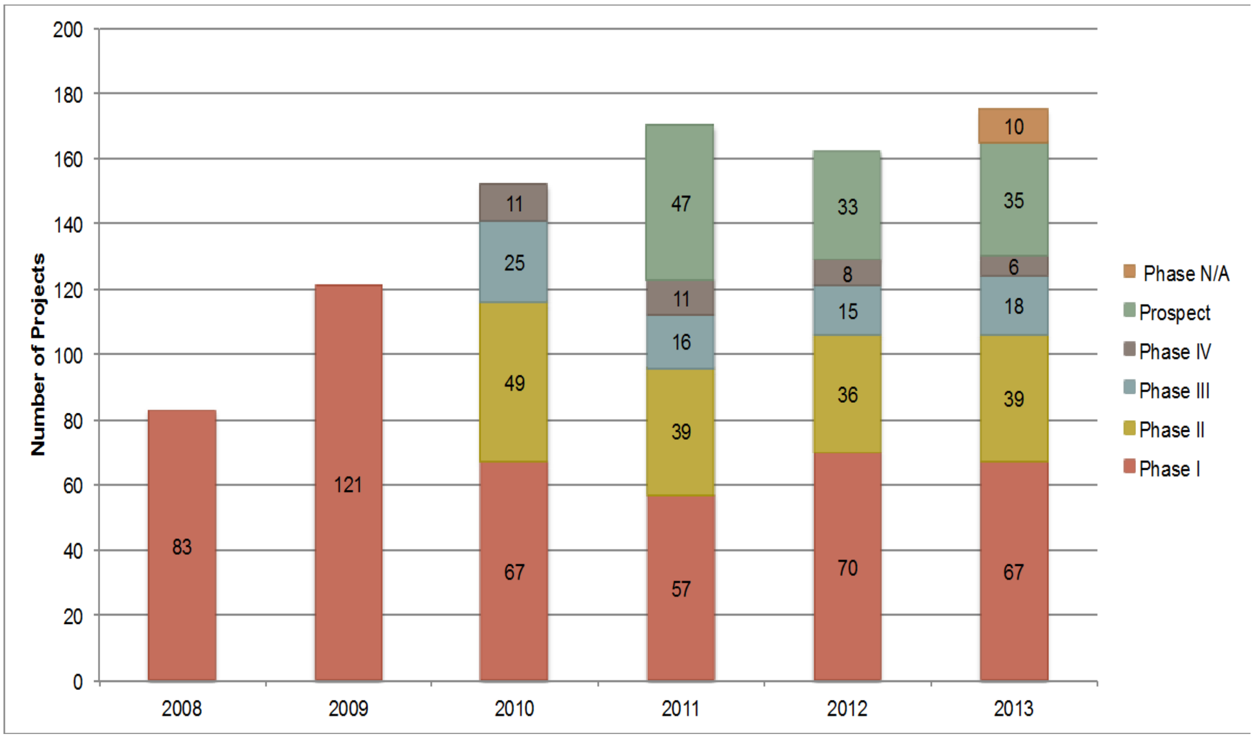

Figure 2. Total projects by year and phase (including unconfirmed projects) (GEA 2013)[4]

1.2 Purpose and Scope

This report focuses on hydrothermal technologies as they are the most commercialized in the United States; we do not focus on other innovations, such as enhanced geothermal systems (EGS) and co-production. Because of their unique risk profile, hydrothermal geothermal projects benefit from different policy structures than other renewable energy technologies to support their

[4] See Figure 1 for a definition of Phases I, II, III, and IV. When a developer gains access to a geothermal resource but has not yet completed the steps to qualify as a phase I, this is termed as a "prospect." Note that the 2008 and 2009 GEA surveys did not report the project phases.

deployment. The purpose of this analysis is to help inform policymakers of options that could be used to support geothermal exploration based on previous policy experiences, including those outside of the United States. We have focused on the five general policy types noted below because they are believed to have the most applicability to the U.S. policy context. With the exceptions of drilling insurance and government-led exploration, all other policies can support other phases of geothermal activity (not just exploration); however, these same policies can be designed to specifically encourage geothermal exploration. Note that several countries have customized policies to suit the needs of their geothermal markets and deployment goals, and in doing so, have created hybridized structures that are described in greater detail in the country sections included later in this report.

- **Loan guarantee**—A government or other public entity provides a guarantee of debt repayment to a lender in the event of borrower default; a loan guarantee does not provide for a loan itself.
- **Drilling failure insurance**—The developer pays a premium to access a government-provided partial-cost reimbursement in the event of a drilling failure or a less-than-expected level of success.
- **Lending support mechanism**—A government entity reduces the cost of a loan in a variety of ways. The government can work with a private lender to provide a loan program and can buy down the interest rate charged. Other options include longer interest rates, interest-free periods, and payment-free periods, all of which would likely apply only under a government-provided loan program.
- **Grants and Cooperative Agreements**—These include cost-sharing schemes or other forms of direct payment intended to reduce the investment cost during early-stage development.
- **Government-led exploration—**A government entity leads, partners, or contracts work to identify and prove new geothermal resources. The proven resource may be subsequently transferred (e.g., via a tendering process) to a private sector entity for project development, operation, and/or ownership.

We deemed some countries' policies to be highly unlikely or impractical in the U.S. market and policy context, and thus omitted them from this report. For example, the Government of Kenya has compensated for a general lack of private investment in the country by operating a nationalized geothermal development company that is largely capitalized with aid funding (with additional funds deriving from national tax revenues).

This report also discusses three multilateral agency programs that include risk mitigation instruments whose design could be replicated by the United States. Although these programs were or are funded by donors and are intended to spur development in less-developed countries, they nonetheless provide an instructive example of how to address geothermal resource risk.

Furthermore, some of the countries discussed in this report have a very small amount of identified hydrothermal resources (e.g., Australia, Germany, and France) and have designed their policies to support geothermal heat projects and/or enhanced geothermal systems (a technology that is, as of this writing, not yet fully commercialized).[5] We have included these countries and their policies in the analysis because the policy structures are relevant to hydrothermal applications in the U.S. market.

1.3 Report Organization

Section 2 begins the analysis with an overview of the countries discussed in this report. Each country is assessed according to the following:

- Installed geothermal capacity
- Estimated geothermal resource potential
- Proportion of geothermal capacity to total installed capacity
- Sources of financing and utility regulatory context
- Current policy mechanisms supporting geothermal project development.

Section 3 looks further into the U.S. context with a brief history of its support of geothermal development at the federal level, including exploration policies.

Section 4 provides conceptual descriptions of each of the five general policy types. Here, we describe the abstracted form of these policies, separate from their practical applications. The organizing principle of this section is "leverage" or the level to which a policy can incentivize private investment with public funds.

Section 5 discusses the in-country applications of the five policy types. This section is organized by country instead of policy type (as is Section 4) because in practice, the divisions between these policies are not always clear or countries have employed multiple policies, making it difficult to categorize a country under a single policy.

Section 6 assesses the characteristics of the five policy types (according to megawatts deployed and private investment leveraged), bringing together insights from the case studies examined in Section 5 and analyzing each policy's applicability to the U.S. policy context.

Section 7 provides suggestions on innovative policies that could support geothermal exploration, concludes the report, and proposes areas for further research.

[5] Ormat Technologies put into service the first grid-connected geothermal plant powered by an enhanced geothermal system in April 2013 (EERE 2013). The plant has an estimated capacity of 1.7 MW.

2 Country Context

Table 1 summarizes the political, economic, and geothermal market context for each of the countries discussed in this report, as well as the policy types that have been used within the countries.

It should be noted that five of the top ten countries in terms of installed geothermal capacity are not included below because we could either not identify any exploration policy regimes or those regimes were deemed not applicable to the United States due to the structure of the U.S. electric utility sector and the institutions that are available to provide incentives. These five countries not included, in order of installed capacity, are the Philippines, Mexico Italy, El Salvador, and Costa Rica (BNEF 2012). The Philippines is not included in the main analysis because the state-owned national oil company *developed* nearly all of its existing geothermal capacity. However, a description of the Philippines's geothermal development is included in Appendix A because the country recently privatized the national oil company and enacted a number of policies designed to support geothermal development along with other sources of renewable energy. Also included in Appendix B is a brief discussion of the Government of Kenya's unique approach to geothermal exploration led by a state-owned enterprise. We were unable to identify the policy regimes Italy, El Salvador, and Costa Rica. And as of the time of writing this report, Mexico was formulating but had not yet enacted a program to provide insurance and financing for geothermal exploration activities; for more information, see: https://www.climateinvestmentfunds.org/cif/sites/climateinvestmentfunds.org/files/Mexico%20Geothermal%20Risk%20Mitigation%20Facility%20-%20public.pdf.

Table 1. Summary Information for Countries Examined Herein

Country and Installed Capacity Rank	Geothermal Information	Background	Exploration Support Type
United States **1st**	**Installed Capacity** 3,386 MW **Hydrothermal Resource Potential** 39,090 MW[a] **Percentage of Total Power Grid Capacity** ~0.2%[b]	The United States has a patchwork of deregulated and regulated electricity markets in which power prices are determined by a host of market forces, regulations, and policies. Utilities and power generators can be government-owned or privately held, however most geothermal power generators are privately developed and owned and operated. The federal government has advanced geothermal project development by supporting exploration activities for hydrothermal resources in the 1970s and 1980s and has since provided a number of incentives and supporting policies. States and local governments have also supported geothermal projects; however, these policies are outside the scope of this report.	Loan guarantee; lending support mechanisms; grant.
Indonesia **3rd**	**Installed Capacity** 1,002 MW **Resource Potential** 27,510 MW[c] **Percentage of Power Grid Capacity** 3%[d]	Indonesia's state-owned utility, PT PLN, has a monopoly on electricity distribution and pricing (DOS 2012). Geothermal development is decentralized, with the main developers being state-owned enterprises. However, public-private joint ventures and private companies are increasingly undertaking development activities.	Government-led exploration.
New Zealand **6th**	**Installed Capacity** 731 MW **Resource Potential** Additional 1,100 MW[e] **Percentage of Power Grid Capacity** 7.5%[f]	Due in part to the abundant resource, geothermal power is a significant source of electricity in New Zealand. The country generated 13.7% of its power from geothermal plants in 2012 (Ministry of Economic Development 2013). Although two of the five power producers in New Zealand are now private firms, most of the country's geothermal exploration occurred as the result of government-led efforts (GeothermEx 2010).	Government-led exploration.
Iceland **7th**	**Installed Capacity** 670 MW **Resource Potential** 4,300 MW[g] **Percentage of Power Grid Capacity** 22%	Iceland has a competitive electricity market, although the state-owned firm Landsvirkjun dominates wholesale electricity production with an almost three-quarter market share. Nearly 100% of Iceland's power comes from renewable sources, with about one-quarter of that deriving from geothermal production (Orkustofnun 2011).	Grant; government-led exploration.
Japan **8th**	**Installed Capacity** 535 MW **Resource Potential**	Japan has a deregulated and liberalized electricity sector. Ten regional utilities are responsible for the country's electricity supply and cooperate via the Federation of Electric Power Companies of Japan to promote a stable and efficient national power system. In	Grant; government-led exploration.

Country and Installed Capacity Rank	Geothermal Information	Background	Exploration Support Type
	23,500 MW[h] **Percentage of Power Grid Capacity** ~0.2%[i]	2012, the country was powered by 90% fossil fuels. However, the recently implemented feed-in tariff is expected to spur the renewable energy market (DLA Piper 2012).	
France **18th**	**Installed Capacity** 15 MW in Guadeloupe; no electricity production on mainland **Resource Potential** Low for hydrothermal **Percentage of Power Grid Capacity** Less than 0.2%[j]	France has a liberalized and deregulated electricity sector that is the second-largest in the European Union (behind Germany). Although the country does not have significant conventional geothermal potential in its mainland territory, it does feature the oldest drilling insurance scheme in Europe (developed in 1982). Despite the lack of conventional geothermal resources for power generation on mainland France, the country hosts a prominent enhanced geothermal system research and development facility in Soultz-sous-Forets that includes an operating power plant.	Drilling failure insurance; grant.
Germany **22nd**	**Installed Capacity** 7.3 MW **Resource Potential** Low for conventional hydrothermal **Percentage of Power Grid Capacity** Less than 0.1%[j]	The German power market is the largest in Europe (Maroo 2012). The country is a worldwide leader in renewable deployment, generating nearly 20% of its electricity from renewable resources, though geothermal power represents only a marginal fraction of this percentage (GEA 2012a). The German government is increasing its support for geothermal development—both in domestic and foreign markets—with lending programs through its development bank, Kreditanstalt für Wiederaufbau Bankengruppe (KfW), and premium feed-in tariff rates.	Loan guarantee; lending support mechanism.
Australia **25th**	**Installed Capacity** 0.1 MW **Resource Potential** Low for hydrothermal[k] **Percentage of Power Grid Capacity** Less than 0.01%[l]	Most of the electricity in Australia is delivered through two large electricity markets and two vertically integrated utilities. Currently, the country has minimal geothermal power on its grid with an installed capacity of 0.1 MW. However, in 2009 Australia offered a grant designed specifically to cover a portion of the cost of exploration drilling. Due to a lack of hydrothermal resources, this subsidy is suited toward the development of enhanced geothermal systems, as demonstrated in the Geodynamics-Gooper Basin project discussed with Bendall et al.[m] However, the design of the grant itself could apply to the full range of geothermal energy uses, including conventional hydrothermal. The grant is no longer available.	Grant.

All installed capacity figures are from GEA (2012a) except figures for the United States, which are from GEA (2013); France, Germany, and Australia, which are from BNEF 2012; and New Zealand, which is from Ministry of Economic Development (2012).
Figures for geothermal potentials and percent of total capacity derive from: [a]Williams et al. 2008; [b]EIA 2012; [c]GEA 2012a; [d]Darma et al. 2010; [e]Harvey et al. 2010; [f]Ministry of Economic Development 2012; [g]Íslandsbanki 2010; [h]Akeno and Sugino 2010; [i]GEA 2012a; [j]EIA 2013; [k]GeothermEX 2010; [l]Beardsmore and Hill 2010;, and [m]Bendall et al. 2013.

3 Background on U.S. Federal Geothermal Power Policies Supporting All Phases of Development

The United States leads the world in installed geothermal capacity with 3,386 MW. To reach this point, national and state government agencies employed a number of supporting policies and financial incentives ranging from loan guarantees and tax credits to direct subsidies. During the 1970s, 1980s, and early 2000s, the federal government enacted a number of policies and incentives that helped jump start—and then advance—the geothermal industry. These included:

- The first federal loan guarantee program begun in 1974 (Nasr 1978; Doris et al 2009; Speer 2012). Lead agencies: Energy Research and Development Administration and later the Department of Energy
- The Public Utilities Regulatory Policies Act begun in 1978 (Owens 2002; Doris et al. 2009). Lead agency: Federal Energy Regulation Commission with some responsibilities delegated to states
- The investment tax credit (ITC) begun in 1978 (Doris et al. 2009; Speer 2012). Lead agency: Department of Treasury
- The Industry-Coupled Case Studies Program begun in 1978 (Moore et al. 2010; Speer 2012). Lead agency: Department of Energy
- The production tax credit (PTC) begun in 2005 (Doris et al. 2009; DSIRE 2012; Speer 2012). Lead agency: Department of Treasury.

Most of these programs supported renewable energy development more generally; however, federal programs specifically relevant to the exploration drilling (including the loan guarantee and Industry-Coupled programs briefly mentioned here) are presented in more detail in Section 5.1.

In addition to these older programs, the federal government has enacted or revised a number of policies and incentives since the mid-2000s that provide support to geothermal projects, both in general and potentially to the exploration phase more specifically. These programs were:

- The Section 1703 Loan Program enacted in 2005 and its extension, the Section 1705 Loan Program enacted in 2009
- The Bureau of Land Management's *Programmatic Environmental Impact Statement for Geothermal Leasing in the Western United States*, intended to help streamline the federal leasing system and define a set of best practices for hydrothermal development in the western United States (Doris et al. 2009)
- The ITC, PTC, and changes to these programs including the 1603 Treasury Grant (Speer 2012)
- Support for innovative early-stage drilling technologies through the Recovery Act and DOE Funding Opportunity Announcement #0000522.

4 Policy Descriptions

Below, we define five generic policy types that are commonly used to spur renewable energy deployment in general and, in some cases, geothermal development in particular. Importantly, we have categorized these policy types by their relative leverage or the degree to which public expenditures can attract private investment.

For example, in the case of a loan guarantee program, the government does not actually set aside capital equal to the amount of the private loans that are being backstopped. It merely has to set aside enough capital to cover the probability of defaults in the entire portfolio of guaranteed projects (Mendelsohn 2010). In contrast, when the government assumes the full responsibility of drilling wells and does not incentivize the private sector to do so, the government is accountable for the full cost contributed, not including any exploration activities undertaken by private sector developers (i.e., the exploration could be a joint effort). It is important to note that actual leverage will depend on the specifics of individual policy design.

Finding a balance between leverage and subsidy levels is important because if a subsidy is too high and does not leverage private funds, as in the case of government-led exploration, public funds may be overcommitted and expended rapidly. On the other hand, if a subsidy is too low, very few investors may take advantage of the policy because it may not sufficiently reduce exploration risks.

Due to the emphasis in the United States on market-driven policies with minimal government expenditures, we assessed policies primarily by their ability to leverage private investment. There are several additional ways to assess the effectiveness of a policy, such as total cost, installed capacity, market growth, increase in capital flows, and barrier mitigation. While considering the following analysis of each policy type, it may be helpful to keep in mind that leverage is not the exclusive indicator of policy success.

Table 2 orders the five main policy types analyzed by leverage; the rankings are purely conceptual and do not account for any modifications in policy design or measurements of actual impact.

Table 2. Illustrative Qualitative Assessment of Leverage Capability by Policy

<table>
<tr><th>Low Leverage</th><th>Medium Leverage</th><th>High Leverage</th></tr>
<tr><td>Government-led exploration: Low; government incurs full cost of exploration and investment forfeiture in the case of dry wells</td><td>Lending support mechanisms: Medium; interest from the loans could help defray costs, provided that the default rate remains low</td><td rowspan="2">Loan guarantee: High in the case of limited guarantee payouts

Drilling failure insurance: High in the case of limited claims</td></tr>
<tr><td colspan="2">Grants and cooperative agreements: Medium to low; represent a liability in either the case of direct payouts or foregone tax income</td></tr>
</table>

[a] The assessments of leverage provided here are general comparisons across the five policy types. Actual leverage will depend on the specifics of policy design.

4.1 Loan Guarantees

Loan guarantees are one type of credit enhancement that can strengthen a borrower's ability to take on debt by improving the project's risk profile. Loan guarantees involve three parties: the borrower, the lender, and the guarantor. In the case of a government policy, the guarantor is usually a government agency or public financial institution. In the event the borrower defaults on debt payments, the guarantor pays off the remaining loan to the lender on behalf of the borrower, usually up to some agreed-upon limit (e.g., 80% of the total loan value). Depending on the policy structure, the guarantor may obtain ownership of project collateral in a default situation as a means of offsetting the cost of the loan repayment.

Loan guarantees and loan forgiveness are similar policies with some distinctions between them from a policy perspective, but could both be considered. From the perspective of the borrower, loan forgiveness is similar to a loan guarantee. Under a loan forgiveness program, a government provided loan could either be repayable no matter the outcome of exploration drilling, or partially or fully forgivable in the case of unsuccessful drilling. This can take the form of a loan being transformed into a grant (in which case, no payment is required). An example can be found in Germany's "Risk of Non-Discovery of Deep Geothermal Energy" program, described in detail in Section 5.3. Thus, under either type of program, the borrower is no longer obligated to repay a portion or all of a loan in the event the project is "unsuccessful" as defined by a given program.

As best as possible, loan guarantee programs need to accurately assess the risk of default to ensure loan defaults can be covered and also to accurately communicate the potential cost of the program to the public.

4.2 Drilling Failure Insurance

Drilling failure insurance—also referred to as geologic risk insurance or exploration risk insurance—transfers risk from one party (the originator of the risk) to another (the insurer) in exchange for payment of a premium that reflects the probability of a loss occurring because of that risk. In the case of geothermal drilling, the developer collects a payout if exploration drilling is unsuccessful per a predetermined definition of success. By shifting some of its risk exposure away from its balance sheet, the original party has preemptively managed, in theory, a portion of its potential losses. Financiers that are confident their investments are partially backstopped by creditworthy entities (e.g., a reputable private insurer or national government) may be more likely to furnish capital (and perhaps on more favorable terms) than would be possible without the insurance.[6]

A drilling failure insurance program can be a potentially high-leverage policy option, provided the insured pool of projects have a success rate that is as high or higher than anticipated (and thus revenue from premiums collected cover all claims). Similar to loan guarantees, administrators of drilling failure insurance programs also need to plan for the expensive due diligence process to assess the project risk; however, this could be covered as part of the premium.

[6] Traditional commercial lines of insurance, such as property and liability policies, do not necessarily function as credit enhancements. These policies are required as per the project's contracts (e.g., feed-in tariff and financing agreement), and development will not proceed without them in place.

4.3 Lending Support Mechanisms

Lending support mechanisms, or "soft" loans, directly reduce the cost of financing as compared to loan guarantees and drilling failure insurance, which indirectly reduce the cost of capital. Like loan guarantees, lending support mechanisms involve a third party, which can be a government agency, public financing institution, or a development bank. The third party provides some form of a capital transfer to the lender for reducing the borrower's financing costs. As discussed in Section 3.1, lending support mechanisms may not provide as much leverage for private investment as loan guarantees or drilling risk insurance; funds are generally paid out regardless of the loan's performance and thus are unrecoverable funds. However, lending support mechanisms could be an effective way to spur market development and thus may leverage a large amount of private investment. There is the potential with lending support mechanisms that financiers may have a conflicting incentive to charge higher rates on top of the government subsidy. Checks must be in place to ensure the borrower is actually obtaining a lower financing cost.

There are multiple ways to subsidize both public and private loans, including the following:

- Private loans
    - *Interest rate buy-downs* in which a public entity pays a portion of the interest rate required by the private lender
- Government-provided loans
    - *Lower interest rates*, which can be provided via a direct loan from a public entity
    - *Interest-free periods* during which no interest accrues on the outstanding capital
    - *Payment-free periods* in which the borrower makes no payments to the lender, although interest may continue to accrue
    - *Longer loan terms* than what could be found in the private market, thereby reducing payment levels (although the cumulative interest cost could be higher with a longer amortization period)
    - *Repayment bonuses* or small grants that are received as a reward for timely repayment of a loan.

4.4 Grants and Cooperative Agreements

Grant and cooperative agreement programs (grants), unlike drilling failure insurance or loan guarantees, immediately reduce the private investment required for the high-risk exploration phase. Furthermore, grants are less risky to the project developer than tax incentives. The developer receives the value of the incentive right away, which is not dependent on the developer's future, unknown income levels in order to monetize the incentive. Generally, grants can take the form of direct grants of a set amount or a cost-share that covers a predetermined percentage of total exploration costs.

Another type of grant is a *repayable grant.* A repayable grant is similar to loan forgiveness and is repaid to the government entity in the event a project meets a predetermined level of success. By recouping public funds when a well is successful, this method can help increase the leverage and sustainability of the program. However, it may provide a disincentive for fully developing a project if it is on the borderline of being successful and depending on the level of the grant. Thus, the grant must be high enough to incentivize risk taking without being so high that it is more lucrative to take the grant than to develop a project.

Some grants may come with stipulations or conditions. Matching-funds requirements oblige the developer to raise a predetermined ratio of outside investment, leveraging the public outlay. In another example, programs may require developers to provide data about the hydrothermal resources encountered during the exploration process for the dual purpose of: (1) lowering the risk of future exploration and (2) improving industry processes and technologies. Stipulations and conditions can help government agencies address goals beyond simply drilling more wells. But these same requirements can also make the exploration process more onerous and expensive for the project developer.

4.5 Government-Led Exploration

A government ministry, agency, or government-run utility may contract work to private industry to identify and explore a geothermal resource. Likewise, a government-run utility could undertake this work directly. Subsequently, the government entity may either:

- Issue a tender for a private developer to build and operate a power plant at the site of a proven resource or do so itself
- Execute land lease agreements with developers if an identified but unproven resource is on public lands.

With a government-led exploration program, the government may pay only a portion or all of the exploration expenses.

The goals of direct government participation in geothermal exploration may vary. One goal could be to reduce barriers to private investment by reducing or eliminating the risks of the initial resource identification and exploration phases and may be applied when the risks are perceived to be too high to be addressed by other policies. Another goal could be that of the government-run utility wanting to add to and diversify the energy mix, address unmet power demands, or operate a profitable enterprise.

5 Exploration Policy Case Studies

The following section presents select case studies of the policies that are the focus of this report. These case studies were selected based on their applicability to the U.S. market and are organized by country rather than by policy type as some countries have implemented multiple policies. Each sub-section begins with a brief summary of the geothermal market in the particular country to provide contextual detail and then discusses the primary details of the policies involved.

A number of these examples do not correspond directly to the stylized policies presented above. Some illustrate the different ways that the five main policy types have been combined or adapted to specific national contexts.

In Section 6, we discuss the policy examples together and the applicability of the various policy types to the United States.

5.1 United States: Loan Guarantees, Lending Support Mechanisms, and Grants and Cooperative Agreements

The United States has an installed capacity that exceeds that of any other country by more than 1 GW. Most existing hydrothermal power plants in the United States are concentrated in California and Nevada, but significant resources remain untapped in these and other states. The U.S. federal government and some states have attempted to support additional capacity additions with a variety of policies designed to incentivize private sector development beyond what might occur solely due to market forces.

The policies described below are those that have directly or indirectly provided support to the exploration phase of the project development cycle; a fuller list is included in Section 3. Though the United States has implemented several other measures to support the geothermal market (see Section 3), the focus of this analysis is policies specifically applicable to the exploration phase.[7] For example, from 2009 to 2011, projects were eligible for the 1603 Treasury Cash Grant but could only receive the grant after becoming operational.[8]

The list of policies included within this report is not intended to be comprehensive, but rather it highlights a few key programs that are most relevant to the scope of the report, which focuses on policies to encourage the private sector's exploration of geothermal resources. For example, we do not include a discussion of the Program Research and Development Announcement because it focused on feasibility studies only (Lund et al. 2012). We also do not include analysis of the

[7] Additional policies implemented at the federal level in the 1970s to support geothermal (and other renewable energy technologies) included research, development, and deployment funding; the Public Utilities Regulatory Policies Act; and an investment tax credit (Doris et al. 2009).

[8] A project is operational once it is online and feeding power into the grid or directly to an end-user at the full level of intended capacity.

state-coupled case studies program as it provided support to states and universities, whereas the focus of this report is public-private partnerships.[9]

The United States has provided two loan guarantee programs: one direct loan program, and one cost-share grant both of which could have been applicable to the exploration phase of hydrothermal geothermal projects. Additionally, the federal government has supported exploration for geothermal heat and combined heat and power projects. We have included these programs because the support mechanism may be applicable to supporting exploration activities more broadly, regardless of the intended end-use. We have omitted a discussion of the Section 1703 Loan Program in this section because it has not supported any geothermal projects to date,[10] and because we do explore the Section 1705 program, which is similar to the 1703 program in its design.

Table 3 summarizes the programs that are reviewed in greater detail within this section.

Table 3. U.S. Loan Guarantees, Lending Support Mechanism, and Grants and Cooperative Agreements

Year	Policy Name	Notes
Loan Guarantees		
1974	Loan "Guaranty" Program	The original geothermal loan guarantee program was enacted with passage of the *Geothermal Energy Research, Development and Demonstration Act* in an attempt to catalyze private lending to geothermal projects.
2009	Section 1705 Loan Program	This program was enacted by the Recovery Act as an addition to the 1703 Loan Program. The 1705 program was originally funded with $6 billion, but this amount was later reduced to $2.5 billion and included some modifications compared to the 1703 program.
Lending Support Mechanisms		
1980	Loans for Geothermal Reservoir Confirmation Program	Authorized by Congress, the program was intended to provide exploration loans to both geothermal power and heat projects. Power projects could borrow a maximum of 50% of project costs, but they were not to exceed $3 million. Although authorized, the program never received congressional appropriations.
Grants and Cooperative Agreements		
1977	Program Opportunity Notices (PONs)	This program offered a cost-share to geothermal heat projects for exploration drilling and the demonstration of geothermal energy uses, including combined heat and power.
1978	Industry-Coupled Case Studies Program	This cost-share mechanism covered 20% to 50% of the exploration and reservoir confirmation costs. In exchange, developers had to provide drilling and well data.
1980	User-Coupled Confirmation Drilling Program	Along the same lines as the Industry-Coupled program, the User-Coupled program provided cost-share grants to conduct exploration drilling for geothermal heat projects. The government's portion of the expenses ranged from 20% to 90%, depending on the degree of success achieved in the drilling.

[9] For more information on these and additional exploration programs, such as the Geothermal Resource Exploration Development and Cascades Cost-Share, see: http://www1.eere.energy.gov/geothermal/pdfs/geothermal_history_1_exploration.pdf.

[10] The reason the 1703 program has not supported geothermal projects is likely because conventional geothermal projects are not considered "innovative clean technologies" as required by the program guidelines.

5.1.1 1974 Geothermal Loan Guaranty Program

In the 1970s, geothermal projects struggled to access commercial loans because lenders were reluctant to invest in an unfamiliar technology (Owens 2002). The original geothermal loan guaranty program was enacted in 1974 with passage of the *Geothermal Energy Research, Development, and Demonstration Act* (Bloomquist et al. 2005; DOE GTP 2012b).[11] It was created to address this reluctance among private industry investors by having the federal government share the risk of early-stage geothermal project development (Owens 2002). The program, which came into effect June 25, 1976, was the first loan guarantee in the United States to support the development of energy resources (Nasr 1978). Specifically, it was established to underwrite loans for the:

1. Determination and evaluation of the resource base
2. Research and development with respect to extraction and utilization technologies
3. Acquisition of rights in geothermal resources
4. Development, construction, and operation of facilities for the demonstration or commercial production of energy using geothermal resources
5. Construction and operation of new commercial power plants.

Step 1, the "determination and evaluation of the resource base," could have included exploration efforts, and others have suggested that supporting exploration activity was in fact one of the objectives of the program (Nasr 1978). However, no exploration projects were supported under this program.

In 1978, Congress amended the 1974 *Geothermal Energy Research, Development and Demonstration Act* with the passage of the *Technical Amendments to the Geothermal Energy Research, Development, and Demonstration Act*. The amendments included raising the maximum guarantee amount to $100 million per project (for a total of $200 million per borrower) and pledging the "full faith and credit of the United States" for payment of the guaranties (Nasr 1978).[12]

Projects were given priority consideration for loan guarantees if they:

- Held the possibility of rapid energy production from geothermal resources
- Demonstrated or used new technologies
- Demonstrated or exploited new geothermal resource areas with commercial potential.

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[11] This Act provided several other important programs to support the U.S. geothermal market. Title I included a provision for the "Geothermal Energy Coordination and Management Project to conduct resource inventory and assessment; conduct research and development; initiate a program to design and construct geothermal demonstrations plants; and provide for scientific and technical education programs through the National Science Foundation" (Nasr 1978). In addition to the loan guaranty program, "Title I provides for the establishment of … assistance in the payment of interest charges, and establishment of the Geothermal Resources Development Fund" (Nasr 1978).

[12] Although the reason for including the "full faith and credit of the United States" clause in the amendment is not known, it was likely done to indicate to lenders and investors the unconditional guarantee that would be provided by the federal government in the event of borrower default.

Although the program was designed to support exploration activities, projects that proposed geological or geophysical exploration or the acquisition of land or leases received lower priority when being considered for loan guarantees (Nasr 1978). More information on why this occurred could not be found, although it could have been due to the perceived risks and the related longer project development times. Additional prioritizations were applied that could have impacted the ability of exploration projects to access guarantees (Nasr 1978).

Under the program, the maximum loan term was the lesser of 30 years or "the expected average useful life of any major physical asset to be financed by such [a] loan" (Nasr 1978). Originally, the program guaranteed 100% of loans for up to 75% of projects costs, with the applicant contributing the remaining 25% of capital as equity (Nasr 1978). The program was amended in 1980 to guarantee up to 90% of costs (Bloomquist et al. 2007). This decrease in the equity requirement was likely intended to address the issue—raised by industry during the U.S. House of Representatives' Sub-committee on Energy Research, Development, and Demonstration meetings on the geothermal loan guaranty program—that the 25% equity requirement had been unappealing (Nasr 1978).

The coverage ratio for the program was originally 1:4 and was later reduced to 1:7 by the appropriations committee (Nasr 1978).[13] We could not determine why the appropriations committee altered the coverage ratio. It is possible the committee chose to increase the leverage of public to private dollars to support additional projects.

In addition to the minimum equity requirement, developers supplied project data, and lenders submitted financial reports as part of the guarantee application. Relevant project data included environmental reports; geological, geophysical, and geochemical data; well data; the utilization process; financial information about the firm; project economics; management capabilities of the firm; a milestone plan describing the project goals; marketability of the resources; legal data concerning the project's assets, leases, pending litigation, patents, and permits; and the structure of the organization (Nasr 1978). The loan guarantee application included a description of the management experience of project staff; audited financial statements; the loan agreement; and the lender's assessment of the borrower's loan application. Developers could have included multiple site locations in an application (Nasr 1978).

As of February 1978, three loan guaranties had been issued and six applications were under review (Nasr 1978). An estimated 38 additional loans were being prepared with another 12 potential applicants (Nasr 1978). At the conclusion of the program, eight guaranties had been granted (DOE IG 1987). Thus, it seems likely that a significant number of applicants were either not granted guarantees or that applications were rescinded by the developers. The program was scheduled to expire in 1984 and was ended due to a lack of congressional appropriations (Bloomquist et al. 2007; GAO 1980).[14]

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[13] The coverage ratio is the amount of funds allocated per loan to cover one potential failed loan; it represents one way to understand the perceived risk profile for a given loan guarantee program. The coverage ratio is akin to what is known as the "credit subsidy cost" under the present-day loan guarantee programs. The credit subsidy can be covered either by appropriations or a fee paid by the borrower (DOE LGP 2012).

[14] Information could not be found concerning when the last guarantee was made or exactly when the program ended.

Although the original loan guarantee program did support some geothermal development, several projects defaulted on loans, thereby requiring the federal government to make the loans whole (Bloomquist et al. 2007). In all, DOE backed $178 million in defaulted loans from three of the eight projects that received loan guaranties. These projects are outlined in Table 4. For a complete list of geothermal projects that received cost-share or loan guarantee support, see Bloomquist et al. 2007.

Table 4. Geothermal Project Defaults on Original U.S. Loan Guaranty Program

Project	Date of Loan Guarantee	Date of Default	Amount	Project Capacity	Type
Westmorland Development Project	1979	1984	$29 million	55 MW	Exploration and field development/electrical
CU-1 Venture	1980	1984	$49.4 million	Unknown	Exploration/electric
Niland Development Project	1984	1985	$99.6 million	49 MW	Electrical

Sources: Bloomquist et al. 2007; DOE IG 1987; GAO 1980

According to Nasr (1978), the original Geothermal Loan Guaranty program had a minimal effect on spurring geothermal development, the result being that response to the program in its first four years was much less than anticipated. Nasr argues that other policy changes, such as the streamlining of environmental regulations and the lease application and granting process, as well as the granting of tax write-offs and depletion allowances would have had a greater impact on geothermal development. Nasr (1978) also claimed that the guarantee program did not encourage any new projects that would have otherwise not happened without the guaranty—in other words, the loan guaranty program did not result in additional projects. Other policy changes occurred in the early 1970s, such as implementation of regulations for the federal leasing program, which were not completed until December 1973. The first lease sale was made in January 1974.

According to Bloomquist et al. (2007), the two main limitations for the loan guarantee program were the:

1. Severe eligibility requirements that resulted in loan guarantees being granted to projects that would likely have qualified for conventional loans
2. Reluctance by utilities to participate in the program due to concern about the impact of default on their credit ratings.

Nasr (1978) also noted several specific barriers to an effective loan guarantee program for geothermal exploration projects:

- **Aversion to supporting risky, exploratory projects**: Although the original program was established to support exploratory, high-risk projects that could otherwise not gain financing, the program itself considered the exploration projects to be too risky. However, no official regulations or laws stated that non-exploration projects should be given priority.

- As an example, as of 1978, one exploratory project—the Beryl and Lund project under development by Geothermal Kinetics—applied for a loan guarantee. Project developers sought support for completing exploration work, drilling temperature gradient holes, and drilling a test well at each site. Geothermal Loan Guaranty administrators determined that these exploratory efforts were too risky, but the program did grant a guarantee for another Geothermal Kinetics site—the Brawley site in Imperial Valley, California, to support completion of test wells.

- **Long application timeframes**: The average time for the three loan guaranties that went through the application process as of 1978 took 16 months, nearly 9 months of which was spent under government review. The application process involved a minimum of 26 steps.
- **Lack of formal application review procedure.**
- **Administrative burden:** The agencies tasked with implementing the program may not have had the organizational capacity to handle the administrative burden of reviewing applications within the timeframes prescribed by the program itself.
- **Variances in application quality often required additional iterations to provide complete applications.**
- **Absence of clear approval authority among the various organizations involved in the review process.**

In addition to avoiding these barriers, loan guarantee programs in general are advised to establish secure and efficient mechanisms for obtaining collateral in the event of a loan default. An audit of the program by the DOE Office of the Inspector General reviewed the collateral procedures for the three defaulted loans and recommended that DOE (1) refer all cases to the U.S. Attorney General to maximize the value of collateral recovered and (2) prepare final plans to expedite recovery of collateral (DOE IG 1987). These recommendations were in response to long delays in recouping collateral from projects in default. The delays resulted in added costs and a decline in the value of the collateral. Accessing collateral quickly and without additional legal wrangling can help a program keep its overall total losses to a minimum.

Under a loan guarantee for geothermal exploration, the ability to recover collateral could be limited because the developer has yet to obtain any significant assets, such as a power plant. Accounting for the limited collateral in the policy design of any loan guarantee targeting the exploration phase is important for determining the overall cost of the program and how the cost may need to be covered via other means, such as a fee paid by the developer.

5.1.2 Section 1705 Loan Program—2009

In 2009, Congress enacted the Section 1705 Loan Program when it passed the Recovery Act. The Section 1705 Loan Program supported commercialized clean energy projects and manufacturers as an addition to the Section 1703 Loan Program passed in 2005. The 1703 program is omitted from this report, as it has not supported geothermal projects in the past and there is no expectation that it will in the future either (Speer 2012).[15] The Section 1703 program is also similar to the Section 1705 program, and thus a description of one is deemed sufficient.

Unlike the 1703 program, the Section 1705 Loan Program applied to conventional geothermal projects. The 1705 program provided for an important programmatic change: it allowed applicants to participate in DOE's Financial Institution Partnership Program (FIPP). Under FIPP, a private industry lender is required to: (1) be the applicant, (2) fulfill the financial and other due diligence considerations, and (3) provide a certification to DOE that the application is accurate and complete (Pillsbury 2009). In other words, FIPP transfers much of the due diligence from DOE to the private industry lender, which has impetus to conduct accurate assessments due to its "skin in the game" with only 80% of the loan guaranteed. The program was originally funded at $6 billion, which was reduced to $2.5 billion after reallocations (Mendelsohn 2010). The maximum guarantee per project was $500 million (Recovery Act 2009).

FIPP was targeted for commercial projects using relatively simple finance structures and those that had credit ratings of "BB" (S&P or Fitch) or "Ba2" (Moody's) (WSGR 2009; Mendelsohn 2010). Projects were limited to 80% debt, and the program would cover 80% of the loan, or in other words, the program would cover up to 64% of the total capital (Martin 2009; Mendelsohn 2010). Fees, including those for the application, facility, and maintenance for the program varied by loan size but roughly equaled 1% of the loan amount (Mendelsohn 2010).

For each guarantee, the federal government set aside a credit subsidy or a percentage of the total amount toward a pool of funds to cover any losses (Jaffe 2009; Mendelsohn 2010). The credit subsidy is estimated to have been between 6% and 10% of each loan amount, and thus it has been calculated that the program could have supported between $25 billion to nearly $42 billion in total loans for all renewable energy technologies (Mendelsohn 2010). The program expired on September 20, 2011.

As shown in Table 5, four geothermal projects were awarded loan guarantees under the 1705 program; however, one developer retracted its application before it was complete. Two of the three projects that went through with the loan guarantee used FIPP, including the three bundled Ormat plants: Jersey Valley, McGinness, and Tuscarora. In all, the 1705 program could support 180 MW of installed capacity and $545 million in loans for geothermal projects pending project completion.

[15] Section 1703 Title XVII of the 2005 *Energy Policy Act* provided for the Section 1703 Loan Program, which allows the federal government to ensure the repayment of loans for qualifying "innovative" clean technology projects, such as geothermal. However, only new technologies that have had "no more than three implementations that have been active for more than five years" are eligible. This requirement would seemingly make most geothermal projects ineligible for the 1703 program.

Table 5. Geothermal Project Recipients of Federal Loan Guarantees

Project(s)	Developer	Lender	Program	Amount[a]	Capacity	Issued
Blue Mountain	Nevada Geothermal Power Co.	John Hancock	1705, FIPP	$99 million - closed	36 MW	9/2010
Neal Hot Spring	U.S. Geothermal	Federal Financing Bank	1705	$97 million - closed	23 MW	2/2011
McGinness, Jersey Valley, Tuscarora	Ormat Nevada	John Hancock	1705, FIPP	$350 million - conditional	121 MW	6/2011
RETRACTED: Wister, CD-4, Dead Horse Wells[b]	Ormat Nevada	John Hancock	1705, FIPP	$330 million	80 to 90 MW	N/A

Sources: Brightenergy.org 2010; GEA 2010b; Scharfenberger 2011; Ormat 2010a; Ormat 2010b

Of the five plants supported by the three guarantees that proceeded, three plants (Blue Mountain, Tuscarora, and Jersey Valley) are in operation and two projects (Neal Hot Springs and McGinness) are nearing completion (Neubauer 2012; GEA 2012; U.S. Geothermal 2012). It should be noted that both the Blue Mountain and Jersey Valley projects were already in development when granted the loan guarantee (Neubauer 2012; GEA 2012), and thus the guarantees did not support exploration efforts for those projects. Whether the loan guarantees supported or encouraged exploration for the other projects is unclear. However, the 1705 program was capable of facilitating low-cost financing (e.g., a 4.14% interest rate for one project granted a guarantee) (Nevada Geothermal Power 2011).

DOE awarded $545 million in loan guarantees to geothermal projects, while solar photovoltaic and concentrating solar projects received $13.5 billion under the 1705 program (Speer 2012). Possible reasons for the difference in amounts awarded include perceived high transactions costs by developers, disinterest among lenders to participate in the program, lack of geothermal and DOE program expertise on the part of lenders, and a perception of higher risk due to the pursuit of a loan guarantee (Speer 2012). Another possible reason for the limited use of the 1705 program may have been the mismatch between the extended geothermal development process and the short timeframe for participation in the 1705 program (Speer 2012). In light of the timing mismatch of the 1705 program included in the Recovery Act, geothermal project developers and lenders may be able to better use future loan guarantees if they are available over a longer period of time. Also, projects need to be of a certain size to make economic sense given the added cost of going through the loan guarantee application process, which may deter smaller projects.

5.1.3 Loans for Geothermal Reservoir Confirmation Program

Congress authorized the Loans for Geothermal Reservoir Confirmation Program, a direct loan program, in 1980. It was intended to provide loans to geothermal heat and power projects for surface exploration and drilling (Bloomquist 2005; Bloomquist 2007). Loans could not exceed $3 million and were limited to 50% of project costs for power projects. Despite being passed in the Energy Security Act of 1980 and authorized by the Secretary of Energy, the program never received congressional appropriations.

5.1.4 Program Opportunity Notices

The PONs program offered by DOE in 1977 and 1978 was a cost-share exploration drilling grant intended primarily for geothermal heat projects (Bloomquist 2005; Bloomquist 2007; Lund 2012; Moore et al. 2010). Combined heat and power projects were also eligible. DOE received 22 applications for the program and issued at least one PON for a geothermal power project, which was never completed (Moore et al. 2010). Interestingly, the one PON issued specifically for a power project included a provision permitting DOE to recover up to 50% of the grant from the revenues generated.

5.1.5 Industry-Coupled Case Studies Program

DOE implemented the Industry-Coupled Case Studies Program in 1978. The program had two main objectives. First, its cost-share mechanism helped facilitate geothermal exploration by offsetting some of the high initial costs and risk of exploration drilling. At the time, little was known about the locations of geothermal resources in the United States (Moore et al. 2010). To encourage exploration, DOE covered 20% to 50% of the exploration and reservoir confirmation costs for participating projects (Bloomquist 2005). Second, DOE wanted to gather more data on geothermal resources and projects for the purpose of increasing knowledge and thereby aiding in future geothermal power development (Moore et al. 2010). Thus, DOE required industry participants to provide the well and drilling data collected during the exploration process.

During this program, industry partners evaluated 14 sites, eight of which resulted in geothermal power plants. As of 2010, seven of these plants were operating with a combined capacity of 137 MW (Moore et al. 2010); it is possible more plants have come online since then. The program eventually lost congressional support and is no longer in operation.

5.1.6 User-Coupled Confirmation Drilling Program

The User-Coupled and the Industry-Coupled programs served similar purposes but were offered for different end-uses. Through the User-Coupled program, DOE offered a cost-share grant to geothermal heat projects for a range of resource confirmation activities, including drilling (Bloomquist 2005; Bloomquist 2007; Lund 2012). The program offered to cover 90% of project costs in the case of completely unsuccessful drilling and 20% in the case of completely successful drilling (presumably based on the flow-rate and temperature of the geothermal fluid) (Bloomquist 2005). Specific information on how many grants were awarded and their value was not found.

5.2 France: Drilling Failure Insurance and Grant

The geothermal market in France is geographically fragmented. All of France’s conventional geothermal electric capacity (about 15 MW) is located in Guadeloupe, one of its Caribbean departments. In continental France, the Paris Basin and the Aquitaine Basin are low-energy reservoirs that generally do not produce sufficient heat or flow-rates to drive electricity-generating turbines. However, the country does exploit low-energy reservoirs for direct use and drilling for EGS is likely to increase in the near future. There is also a prominent EGS research and development facility in Soultz-sous-Forets that includes an operating power plant. Although the policies described below generally support exploration drilling for direct use or EGS, the mechanisms themselves could apply to hydrothermal drilling as well.

Table 6 summarizes the two programs that are reviewed in greater detail within this section.

Table 6. French Grant and Drilling Failure Insurance

Year	Policy Name	Notes
Grant		
N/A	Grants for Feasibility Studies	This grant program provides up to 50%, but no more than €300,000, of the cost to conduct feasibility studies for heat and power projects. The grant is administered by the French Environment and Energy Management Agency.
Drilling Failure Insurance		
1982	Geothermal Risk Guarantee System	The exploration-phase component of this insurance program provides investors coverage for up to 90% of the cost to drill the first test well in return for a premium payment equivalent to 3.5% of the covered cost in the Île de France region and 5% in all other regions. The program insures the present value of the project once it is in operation. This component does not mitigate exploration risk.

The French Environment and Energy Management Agency (ADEME) administers a grant program to subsidize geothermal energy feasibility studies. This mechanism is somewhat unique in that it does not provide funds for exploration drilling. Instead, project developers—either public or private—can apply for a grant to cover 50% of the cost of a feasibility study for deep geothermal resources, not to exceed €300,000 (GEOFAR 2009a). The available literature does not specify exactly what constitutes a feasibility study according to ADEME; however, the resource identification phase that occurs before exploration drilling generally includes a literature review of existing information and data; geologic surveys leading to a geologic map of the area; geophysical and geochemical surveys; and in some cases, the commencement of temperature-gradient hole drilling (GeothermEx 2010; GEA 2010a).

A consortium of public and private entities also administers the Geothermal Risk Guarantee System, which was the first public insurance program in Europe to address risk in exploration drilling specifically for geothermal projects (GEOFAR 2009a). It has involved two programs: the first one was created in response to the first oil crisis and was in place from 1974 to 1982, and the second has been in place since 1982 (GEOFAR 2009b). These programs have facilitated development of France's two major geothermal resources in the Paris Basin and the Aquitaine Basin, respectively. Although this program supports drilling for power generation projects, all of the wells drilled thus far on the French mainland have been for geothermal heat projects (GEOFAR 2009b).

The current French scheme consists of two mechanisms that have different time horizons and support different stages of geothermal project development. The first mechanism is a short-term insurance program that provides coverage to investors for up to 90% of the cost of the first well if the well does not yield a productive resource. Just as with traditional insurance, this mechanism socializes the risks of geothermal drilling—that is, it allocates the costs of the program among various participants and bundles the proceeds to pay for failed drilling ventures (GEOFAR 2009a). In cases of partial success, the program compensates the participant as necessary to render the project profitable. Compensation is based on an economic model that considers the temperature and flow-rate of the well and the technical, financial, and economic feasibility of the project. The one-time premium to participate in the program is 3.5% of the covered amount in the Île de France region (which includes the productive Paris Basin) and 5% in regions where the risk is higher (GEOFAR 2009b).

The second mechanism is a 20-year insurance contract that guarantees the present value of the well if a resource has indeed been proven. This mechanism compensates a project sponsor in the case of an irreversible decline in the temperature or flow-rate of the well once the project is online and, as such, does not actually support the exploration phase. For this reason we do not provide a more comprehensive review of it.

The Geothermal Risk Guarantee System is managed by SAF-Environment, a partnership of ADEME, Caisse des Dépôts et Consignations (a financial institution under control of the French Parliament), and other private financial entities (GEOFAR 2009b). The program fund is capitalized with payments from participants and project proceeds, investments, and public funds from ADEME (Bezelgues-Courtade et al. 2008).

France currently has another risk guarantee for large groundwater heat pumps (AQUAPAC), but as this technology falls outside the scope of this report, it will not be discussed here.

5.3 Germany: Loan Guarantee and Lending Support Mechanism

Low-energy geothermal resources are being exploited for direct use and combined heat and power applications in Germany, and developers have recently begun to look into deep, hot aquifers and EGS applications (Schellschmidt et al. 2010). The German government and KfW, the national development bank, support the development of geothermal heat and power through a number of policies and financial incentives.

Table 7 summarizes the two programs that are reviewed in greater detail within this section.

Table 7. German Loan Guarantee and Lending Support Mechanism

Year	Policy Name	Notes
Loan Guarantee		
2009	Risk of Non-Discovery of Deep Geothermal Energy	The loan program includes a loan forgiveness provision of up to 100% of the money borrowed by the developer in the case of failed exploration drilling. We have classified this provision as a loan guarantee.
Lending Support Mechanism		
2009	Risk of Non-Discovery of Deep Geothermal Energy	The program offers loans up to €16 million or 80% of the eligible drilling costs for developers to undertake exploration drilling. Because KfW, the lender, is the national development bank of Germany, we consider this program a government-provided loan and have classified it as a lending support mechanism in addition to a loan guarantee.

Germany offers multiple financial support programs for renewable energy projects under the Market Incentive Programme (MAP) that is administered by the German Federal Ministry for the Environment, Nature Conservation, and Nuclear Safety (BMU) and the German development bank KfW (BMU 2012; Wendel et al. 2010). BMU and KfW offer two programs for geothermal power projects: the Risk of Non-Discovery of Deep Geothermal Energy program and the Renewable Energies Programme for Deep Geothermal Energy. For the purposes of this analysis, we do not assess the latter because it does not apply to the exploration phase.

In 2009, Germany launched the Risk of Non-Discovery of Deep Geothermal Energy program (Fündigkeitsrisiko Tiefengeothermie) to minimize exploration risks associated with geothermal projects. The unique feature of this program is that it combines exploration risk mitigation with project financing (Kreuter and Schrage 2010). For the purposes of this report, we have categorized this program as a hybrid loan guarantee and a lending support mechanism because KfW, a government entity, is the lender and offers 100% loan forgiveness in the case of unsuccessful drilling.

BMU and KfW provide this unique financing mechanism via a €60 million revolving loan fund. The maximum loan size for a given project is the lesser of €16 million or 80% of the eligible drilling costs (KfW), with the developer covering the remaining 20%. The loan period can be as long as 10 years. During the drilling period, KfW requires a risk surcharge to be paid in the form of a higher interest rate, usually in the range of 10% to 20%. Additionally, a €65,000 application fee is required along with an additional €45,000 for an approved loan to cover the program's monitoring and auditing costs.

There are two important features of the loan: a one- to two-year grace period during which the developer can defer repayment and a full release from loan liability mechanism. The full release from loan liability is enacted if the developer does not achieve a predetermined success threshold (e.g., if the thermal capacity of a drilled well is less than the required level to make the project viable) (Kreuter and Schrage 2010). If the exemption is enacted, the developer will not be required to repay the loan, and KfW will cover up to 80% of the drilling costs with the developer covering the remaining portion.

An important feature of the Risk of Non-Discovery of Deep Geothermal Energy program is that developers are required to apply for the program through the local commercial bank with which they have a pre-existing relationship. For their part, the commercial bank processes the application and guarantees the loan to KfW in the event the developer goes bankrupt (though this guarantee does not cover drilling failure) (Kreuter and Schrage 2010). The developer's bank also facilitates development of the loan application, which is then submitted to KfW (Kreuter and Schrage 2010). By requiring the bank to guarantee the loan, the program induces the bank to thoroughly assess the risks. Municipalities, municipally owned enterprises, and municipal special-purpose associations can file their loan applications directly to KfW.

The unique feature of this program, as compared with U.S. loan guarantee programs, is that a government entity provides the financing that is guaranteed by a private lender. The U.S. loan guarantee programs, in comparison, represent guarantees provided by the government for debt supplied by private sources. Another unique feature of the German program is that KfW attempts to account for possible losses due to the high risk of geothermal exploration by charging a higher interest rate, called a risk premium, during the drilling phase. Under this feature, the additional interest charged protects public resources from excessive losses; however, the risk premium may prove to be too expensive to increase the level of project activity. Thus, the Risk of Non-Discovery of Deep Geothermal Energy program serves as an example of how one government created a customized approach to supporting its geothermal market by developing an innovative policy that incorporates elements of loans, loan guarantees, and insurance.

Although no data is publically available regarding the number and amounts of loans made under KfW's Risk of Non-Discovery of Deep Geothermal Energy Program, geothermal development in Germany is progressing. As of July 2012, four combined heat and power plants were operating with a total installed capacity of about 7.9 MWe, and another 30 projects were in development (BNEF 2012).

5.4 Multilateral Banks and Development Agencies: Drilling Failure Insurance and Grant

Superficially, the following three programs—Geofund, ARGeo, and the Geothermal Risk Mitigation Facility for East Africa—implemented by multilateral banks and development agencies may not appear to be relevant to the U.S. policy and market context. Geofund is now defunct, while ARGeo has faced serious delays.[16] All three were or are administered and funded through multilateral agencies or development banks. The United States, as a developed country, does not receive funding or other support from multilateral institutions for the development of domestic energy infrastructure, nor does it have a national development bank as do some other developed countries (e.g., Germany). However, the United States could still replicate these risk mitigation mechanisms summarized in Table 8.

Table 8. Multilateral Banks and Development Agencies Drilling Failure Insurance and Grants

Year	Policy Name	Notes
Drilling Failure Insurance		
2006	GeoFund	Established by the World Bank to support geothermal energy development in eastern Europe and central Asia, GeoFund's main mechanism was drilling failure insurance. The World Bank discontinued the program after the pilot program in Hungary failed to confirm sufficient flow-rates and collected a USD $3.3 million claim.
2009	ARGeo	The Global Environment Facility established ARGeo in partnership with other multilateral institutions in order to provide technical assistance and exploration risk mitigation to geothermal projects in the East African Rift region. Originally structured as a drilling failure insurance scheme, the risk mitigation mechanism was eliminated when the World Bank rescinded its funding.
Grant		
2012	Geothermal Risk Mitigation Facility	The German development bank KfW, in partnership with the European Union and African Union, offers grants for geothermal exploration and drilling. The program is targeted to projects in five nations located along the East African Rift. The fund pays additional success fees once the project secures outside funding for subsequent phases of development.

5.4.1 Geofund

In 2006, the World Bank launched the GeoFund, a program to facilitate geothermal development in eastern Europe and central Asia (Shimizaki 2008).[17] The fund was seeded with a $25 million grant from the Global Environmental Facility but was dropped in 2009 after spending its first tranche of about $4.5 million (World Bank).

[16] It is not clear in any of the available program literature why the Geofund and ARGeo programs were discontinued or delayed.

[17] Targeted countries included Albania, Armenia, Azerbaijan, Belarus, Bosnia-Herzegovina, Bulgaria, Croatia, Georgia, Kazakhstan, Kyrgyzstan, Macedonia, Moldova, Montenegro, Romania, Russia, Serbia, Ukraine, Tajikistan, Turkey, Turkmenistan, and Uzbekistan.

The GeoFund program was divided into three component instruments: technical assistance, direct investment funding for projects, and a drilling failure insurance mechanism. The only project that received coverage under the insurance mechanism was a pilot project in Hungary sponsored by the Hungarian Oil and Gas Company (MOL) and geothermal developers Enex (Iceland) and Vulkan Kft (Australia). The project did not proceed to construction primarily because sufficient flow-rates were not discovered in the two test wells. As a result, the drilling failure insurance mechanism was activated, and the World Bank paid MOL $3.3 million out of a coverage limit of $3.72 million (the limit was set at 85% of the eligible drilling cost) (Shimizaki 2008; World Bank 2010).

5.4.2 ARGeo

In partnership with the World Bank and United Nations Environment Programme, the Global Environment Facility established the East African Rift Geothermal Development Program (ARGeo) in late 2009 to provide technical assistance and exploration risk mitigation funding (Mwangi 2010). ARGeo is intended to support operations in six target countries to exploit resources along the seismically active East African Rift that are largely undeveloped.[18]

The original ARGeo proposal took a dual approach: (1) regional networking facilitation and technical assistance and (2) a drilling risk mitigation fund that exclusively addressed exploration-drilling risk. In exchange for a premium paid by the developer, the risk mitigation fund provided up to 85% of eligible drilling expenses in the event that exploration drilling yielded an insufficient resource. This coverage ratio would be reduced for each successive well attempted. The World Bank rescinded its funding for the risk mitigation portion of the project in December 2011, but at the time of writing, the networking and technical assistance portion of the project was still active.

5.4.3 Geothermal Risk Mitigation Facility for Eastern Africa

After pulling out of the planning process for ARGeo, KfW created a geothermal risk mitigation facility in partnership with the European Union and the African Union in late 2011.[19] This program offsets the risk of non-performing exploration wells by providing grants for 80% of the cost of surface studies, 40% of the cost of exploration drilling, and 20% of the cost of required infrastructure improvements (GRMF 2012). Grants are available to both government and private developers. To further incentivize developers, the bank offers an additional financing success fee for projects that secure outside financing for subsequent phases of development (KfW 2011; Muir 2011). Although it offers additional incentives and funding for other activities in addition to exploration drilling, this facility essentially functions in much the same way as the U.S. Industry-Coupled Case Studies program: it is a cost-share program with a data collection requirement.

At the time of publishing, the Geothermal Risk Mitigation Facility had just closed the first round of applications. KfW and the African Union have stated their intentions to expand the facility after it is piloted.

[18] Projects in Ethiopia, Eritrea, Kenya, Rwanda, Tanzania, and Uganda are eligible.
[19] Projects in Ethiopia, Kenya, Rwanda, Tanzania, and Uganda are eligible.

5.5 Australia: Grant

Conventional hydrothermal resources are nearly non-existent in Australia. However, the country has significant potential for developing deep hot aquifers and EGS resources, and the mechanisms Australia is using to support the development of these resources could also be applied to conventional hydrothermal exploration.

Table 9 summarizes the program that is reviewed in greater detail within this section.

Table 9. Australian Grant

Year	Policy Name	Notes
Grant		
2008	Geothermal Drilling Program	Australia implemented a cost-share grant program to support exploration drilling for EGS and deep, hot aquifers. The program provided a matching grant of up to AUD $7 million for drilling activities.

In 2008, Australia introduced the Geothermal Drilling Program to provide $50 million Australian dollars (AUD) for exploration drilling. The government sought to offset a portion of the exploration drilling expenses for a limited number of projects by offering matching grants of up to AUD $7 million. The Australian Department of Resources, Energy, and Tourism issued seven grants through a competitive, merit-based selection process (Australia DRET 2009).

Of the seven grants awarded, four were forfeited. In a report commissioned by the Australian Centre for Renewable Energy, the Allen Consulting Group (2011) noted that the developers found it difficult to raise the required matching funds by the set deadline (due in part to unfortunate coincidence with the global financial crisis); this may have been a primary factor for the forfeitures. The final round of applications closed in August 2009, and all funded projects must be completed by December 31, 2014.

5.6 Iceland: Grant and Government-Led Exploration

Geothermal plants provide a significant portion of Iceland's electricity needs and represent nearly one-quarter of installed capacity and generation. Due to the country's location on the mid-Atlantic ridge, the country has advantageous conventional hydrothermal resources. Another unique aspect of geothermal development in Iceland has been its decentralized and yet public nature. Iceland's government exploration activities date to 1969 when a municipal government constructed the first geothermal power plant in the country. Since then, resource exploration, exploration drilling, development, and electricity production have remained mostly the responsibility of municipal, regional, or national government entities, under the regulation of the National Energy Authority (GeothermEx 2010).[20]

Table 10 summarizes the two programs that are reviewed in greater detail within this section.

[20] HS Orka is the only private firm that operates geothermal power plants in Iceland (Íslandbanki 2010).

Table 10. Icelandic Grant and Government-Led Exploration

Year	Policy Name	Notes
Grant		
2008	National Energy Fund Grant	The National Energy Fund offers a cost-share grant to support exploration activities up to 50% of project costs. The grant is paid out in three equal payments.
Government-Led Exploration		
1969	Government-led Exploration	Geothermal energy development has been led by government entities at both the national and municipal levels. Currently, most exploration still takes place as the result of municipal government and/or utility geothermal development. There is only one private sector entity that operates power plants.

Iceland launched the National Energy Fund in 1967 to provide loans and grants to support geothermal exploration drilling (heat and electricity applications). In 2003, Iceland passed an act that placed administration of the program with the National Energy Authority (Björnsson 2010). The fund includes a few programs for various types of geothermal projects, but hydrothermal exploration is eligible for the fund's grant program only (Government of Iceland 2009). Public and private organizations are eligible for the grant that can cover up to 50% of project costs, making it a cost-share program (GEOFAR 2009c). The grant is paid out in three equal payments: (1) when work begins, (2) when work is halfway done, and (3) when work is complete (GEOFAR 2009c).

5.7 Japan: Grant and Government-Led Exploration

Japan was an early adopter of geothermal energy for power generation. The first commercial plant was commissioned in 1966 (Akeno and Sugino 2010). At over 23 GW, Japan has one of the highest potential hydrothermal resource bases in the world. The power market is restructured and dominated by 10 regional electric utility companies. Geothermal capacity additions have been stagnant since the mid-1990s, but recently adopted renewable energy policies and incentives may be positioning the geothermal industry for a revival.

Table 11 summarizes the two programs that are reviewed in greater detail within this section.

Table 11. Japanese Grant and Government-Led Exploration

Year	Policy Name	Notes
Grant		
2008	Cost-Share Grant	The cost-share grant covers 50% of the cost to drill exploratory wells and 20% for development and injection wells. In recent years it has not been well funded.
Government-Led Exploration		
1974	Geothermal Research Program	The Agency of Industrial Science and Technology (AIST) created a geothermal research program in 1974 in response to the first oil crisis. The program included exploration drilling and was transferred to the New Energy Development Organization in 1980.

In 1974, the Japanese Agency of Industrial Science and Technology (AIST) undertook a large geothermal research program that included exploration drilling (GeothermEx 2010). In 1980, the government transferred responsibility for the program to the New Energy Development

Organization (NEDO). Together, the two agencies funded the research initiative for the purpose of reducing exploration risk and subsequently contracted private firms to undertake the drilling (GeothermEx 2010). As the research initiative identified and demonstrated resource effectiveness, NEDO and AIST transferred their use to private firms to develop them into power plants (GeothermEx, 2010).[21]

In conjunction with its research program, the Japanese government introduced a cost-sharing program to subsidize exploration drilling. Although not well funded in recent years, the program covers 50% of the cost to drill exploratory wells, with 100% repayment required if the wells are successful (Akeno and Sugino 2010). In 1986, the government expanded the program to also cover 20% of the cost of development and injection wells (Akeno and Sugino 2010).

The reduction in risk created by NEDO's cost-share subsidy and research effort may have contributed to geothermal power development in Japan. Installed capacity increased from 139 MW in 1976 to 539 MW in 2011 (BNEF 2012; GeothermEx 2010). Although the cost-share program still existed as of 2010, Japan's geothermal power sector stagnated between 1999 and 2010, adding just 2 MW in 2004 (Akeno and Sugino 2010).

5.8 New Zealand: Government-Led Exploration

New Zealand was an early adopter of geothermal energy. Commissioned in 1958, the Wairakei geothermal power plant was one of the first in the world. New Zealand currently gets a significant portion of its power from geothermal plants, which generated 13.7% of the country's electricity in 2012 (Ministry of Economic Development 2013). This is due in part to the market competitiveness of geothermal power and other renewables in New Zealand, and also to the abundance of hydrothermal resources on the North Island (Harvey et al. 2010).

Table 12 summarizes the program that is reviewed in greater detail within this section.

Table 12. New Zealand Government-Led Exploration

Year	Policy Name	Notes
Government-Led Exploration		
1958	Government-led Exploration	Most of New Zealand's geothermal development occurred when the country's utility companies were government-owned. As such, these government utility companies, and in turn the government itself, carried the risk associated with exploration drilling.

Most of New Zealand's geothermal power development was due to government-led exploration (GeothermEx 2010). Although two of the five electricity producers in New Zealand are now private sector companies, much of the country's geothermal development took place when the government bore the exploration risk, and some of the government-run utilities still undertake geothermal exploration projects today (GeothermEx 2010).

[21] In some cases, NEDO and AIST transferred proven resources to the contracted industry partner in order for them to develop the resources for power generation; in such cases, the cost-share for exploration drilling applied (GeothermEx 2010). We think they may have tendered some of these proven resources as well.

5.9 Indonesia: Lending Support Mechanism and Government-Led Exploration

Indonesia has the highest potential for geothermal power in the world, but with only 1,002 MW of installed capacity, much of the potential remains untapped (BNEF 2012). PT PLN, the state-owned utility, has a monopoly on electricity distribution and pricing. Traditionally, state-owned enterprises and municipal entities conducted geothermal development activities, but public-private partnerships and private developers have started to enter the industry.

Table 13 summarizes the two programs that are reviewed in greater detail within this section.

Table 13. Indonesian Lending Support Mechanism and Government-Led Exploration

Year	Policy Name	Notes
Lending Support Mechanism		
2011	Geothermal Fund Facility	This government loan program provides private sector developers, state-owned enterprises, and municipal government developers with loans for exploration and confirmation from a revolving loan fund. Municipal government entities can access the funding without repayment in the case of failed exploration drilling, while private sector and state-owned enterprise developers must repay the loan with interest, no matter the outcome of exploration drilling.
Government-Led Exploration		
1974	Geothermal Research Program	Until recently most geothermal development had been conducted by government entities, such as state-owned enterprises and/or government-owned utilities. More recently, private sector developers and public-private partnerships have begun to enter the market; however, most existing geothermal plants were the result of government-led efforts.

In 2011, Indonesia created the Geothermal Fund Facility (GFF), a revolving loan fund with an initial capitalization of 1.237 trillion Indonesian rupiah ($145 million USD) designed to help mitigate exploration-drilling risk.[22] The GFF is structured as a public-private collaboration in which local governments or firms (private and state-owned) in possession of either a geothermal mining permit or a geothermal power concession undertake exploration activities (Hasan and Wahjosoedibjo 2012; PIP). The GFF issues loans to these three types of entities to undertake exploration activities.

When a local government receives funding from the GFF, they contract a private firm to undertake the exploration activities, including drilling (Wahjosoedibjo 2012). Once a potential resource proves viable for power generation, the local government can issue a tender for development of the proven resource. Then, the winning bidder must pay for the exploration data in order to receive its mining license. Proceeds from the data and information package purchased by the winning bidder will partially recapitalize the fund (Hasan and Wahjosoedibjo 2012; PIP). After the winning bidder develops a field and builds a power plant, the bidder sells its power to the government-owned utility through a power purchase agreement. The Indonesia Investment

[22] According to an interview conducted for this report, the GFF may no longer be completely "revolving" due to the high risk of geothermal exploration (Wahjosoedibjo 2012). That is, because losses are potentially high, fund designers thought the fund might be drawn down faster than it could be recapitalized.

Agency will likely forgive loans to local governments for any unsuccessful exploration activities (Wahjosoedibjo 2012).

With private or state-owned firms that are holders of geothermal mining permits and geothermal power concessions, GFF funding takes the form of a loan disbursed in stages that is repayable with interest when the entity completes successful or unsuccessful exploration activities (PIP). Because the loan is repayable whether or not the resource proves viable, the entity conducting exploration activities bears all risk of unsuccessful drilling. Private developers and state-owned enterprises that successfully develop steam fields into operating power plants sell their power to the state-owned utility through power purchase agreements.

Because both government entities (such as municipal governments and state-owned enterprises) and private developers develop geothermal resources in Indonesia, the country's policy regime can be categorized as a hybrid lending support mechanism and government-led exploration. The GFF is a government-provided lending program available to private developers, government entities, and public-private partnerships. The state-owned developers and municipal governments that develop geothermal resources give the hybrid regime its government-led character. In the case of local government exploration, the GFF takes on the risk of failed exploration drilling. On the other hand, private and state-owned developers assume all the exploration risk under the GFF. However, this type of government exploration scheme is different from government agencies undertaking exploration drilling and power plant construction directly because the government-owned utility neither develops nor operates the steam field or power plant.

6 Characteristics of Exploration Policies and Applicability to the United States

This section examines which overall policies and/or specific policy components spurred geothermal deployment, along with providing possible explanations as to why they were successful. Each discussion includes an assessment of the appropriateness of a given program to the U.S. policy context. Due to a lack of detailed information beyond what is available publically and the subsequent challenge of linking impacts to a particular policy, this analysis is predominantly qualitative. As in Section 4, the following discussion is organized by potential leverage of private investment (highest to lowest).

6.1 Loan Guarantee

Loan guarantee programs are generally public-private partnerships and involve multiple contracts between several parties. Thus, these programs tend to have complex structures, and their effectiveness can be impacted by many different elements of the policy's design.

It is important for the guarantor to accurately assess the ability of geothermal exploration projects to access loans on the private market. The guarantor must also determine whether providing a loan guarantee will bring down the cost of financing by an amount that will help projects move forward. In addition, these programs have the potential for high losses in the case of loan defaults, although due diligence in assessing project and borrower risks could help mitigate this possibility.

The U.S. 1974 Loan Guaranty and Section 1705 programs described in Section 5.1 would seem to be an obvious fit to be reapplied in the United States. However, for a couple reasons, these programs may not be good candidates for implementation today. First, there may be less political appetite for another loan guarantee program following the high profile bankruptcies and defaults of a few borrowers under the 1705 program. Second, due to fiscal concerns, it may be difficult to gain enthusiasm for a program in which the ultimate cost is unknown. But the creation of a loan loss reserve could make a loan guarantee more appealing. Once the loan loss reserve is expended, any subsequent defaults would be made whole through private channels (i.e., there would be no government backing after a certain amount of defaults).

With regard to a loan forgiveness-type guarantee, such as Germany's Risk of Non-Discovery of Deep Geothermal Energy program, this type of guarantee is less likely to apply to the United States than the traditional loan guarantees previously offered by the U.S. federal government. The United States has no national development bank akin to KfW to administer such an initiative, and the federal government usually prefers to take a more market-oriented approach by incenting private lenders with government loan guarantees rather than providing loans. Furthermore, the KfW program has found it challenging to engage developers' commercial banks because many lack experience assessing the risk of geothermal projects, thereby creating high per-loan transaction costs (Kreuter and Schrage 2010). Programs looking to replicate this model may want to consider how best to engage private-sector lenders in geothermal financing, especially where there has been little experience to date. For example, banks could be provided with training on geothermal technologies and project risks.

However, DOE or another government agency, such as the Federal Financing Bank, could be authorized to provide loans directly with a forgiveness mechanism in much the same way that the Department of Education provides loans for higher education. In fact, the Federal Financing Bank has provided a direct loan to a geothermal project–guaranteed by the Section 1705 Program—in the past. The Neal Hot Spring project recently put into commercial operation by U.S. Geothermal received a non-forgivable loan of nearly $100 million from the Federal Financing Bank (Lowder 2012). Despite this success, most U.S. government agencies do not have the capacity to manage loans directly as KfW does in Germany.

Interestingly, low-cost public-private financing programs have been implemented at the state level, and there were several attempts in Congress and the Senate to establish a government-backed finance institution for clean energy projects in 2009.[23,24] The bills that were introduced died in committee. Generally, using the model of direct loans would convey more risk and less leverage of private investment to public resources as compared to providing loan guarantees.

Another attractive feature of the Risk of Non-Discovery of Deep Geothermal Energy program is that it seeks to support alternative geothermal power technologies, such as enhanced geothermal systems, and it does not require a typically requisite probability of success (POS) study (Kreuter and Schrage 2010). By implementing a similar program in the United States, there is the potential to encourage projects that use technologies or applications beyond those that are currently being commercially developed, such as EGS.

6.2 Drilling Failure Insurance

As demonstrated in the case of the Geofund (Section 5.4), public insurance programs have high leverage potential on a programmatic basis (although claims paid to a given project in the event of an unsuccessful exploration can be high). Provided that these programs can judiciously select clients and diversify risk exposures, drilling failure insurance programs can be a cost-effective and self-sustaining option.

The French example shows how a risk insurance scheme could enable development at scale while containing losses. However, this is due in part to the high success rate of drilling for geothermal heat projects. The available data on the wells drilled in the Paris Basin since 1987 (when France reinstituted its insurance scheme) show a success rate of 74% (with partial failures at 17% and total failures at 9%), which is substantially higher than the rate encountered by geothermal power developers in the United States (Bezelgues-Courtade et al. 2008). In the

[23] Most notably, Senator Jeffry Bingaman and Congressman Christopher Van Hollen introduced separate bills in 2009 that would have established a clean energy financing pool. Included in the American Clean Energy Leadership Act of 2009 (S.1462), Senator Bingaman proposed the Clean Energy Deployment Administration within the Department of Energy to provide financing for clean energy projects. Congressman Van Hollen introduced H.R. 1698 to establish a federally owned, independent "Green Bank" funded by U.S. Treasury bonds.

[24] In 2011 the State of Connecticut established the Clean Energy Finance and Investment Authority with the purpose of leveraging private investment in renewable energy and energy efficiency projects. See www.ctcleanenergy.com for more information. California has two "green bank" institutions as well; see: http://www.treasurer.ca.gov/greenbank/index.asp. If these types of quasi-government "green banks" are established in states with geothermal resources such as California, they could conceivably provide low-cost financing for geothermal projects.

United States, developers can expect a success rate somewhere in the neighborhood of 35% to 50% for well-researched and vetted drilling sites (Speer 2012). If the United States were to implement a similar program, it could potentially offset the lower success rates by charging a higher insurance premium.

Effective risk management entails the optimal balance of returns to risks. For drilling insurance schemes to be self-sustaining, the revenue stream from premium payments must be higher than paid claims. However, premium rates should not be so high as to discourage developer participation.

In addition to the applicability considerations gleaned from the case studies in Section 5, policymakers may want to consider how to provide clarity in the claims-making and payout processes. Clear information about the required capital requirements, policy holder eligibility, the division of payouts between the developer and investors, eligible claims, and the coverage triggers (i.e., at what temperature and flow-rate is the well considered a loss) can help lower the participants' perceptions of policy risk. Specifying how many test wells are eligible for cost recovery and whether there is a declining rate of coverage for each well can also help prevent developers and program administrators from making erroneous assumptions about covered losses.

Government insurance programs currently exist in the United States primarily to allow risk-prone populations without access to the private insurance market the opportunity to protect themselves against certain exposures. Such gaps in private coverage usually exist because either the cost of insurance is out of their reach for those that need it most or insurance for particular risks is not available. The earthquake insurance offered by California is one example. Catastrophes, such as earthquakes and floods, pose potentially devastating and concentrated loss probabilities, and private insurers may risk insolvency if their coverage in these areas is triggered at large scale. Therefore, the federal and state governments have stepped in to meet a need (i.e., the protection of its population) that is in their interest.

If geothermal energy deployment is deemed to be in the national interest (e.g., for the various environmental and energy security benefits it provides), it may be reasonable for policymakers to devise a scheme that mitigates or removes one of its principal barriers: the exploration drilling risk.

An insurance program would likely require some high up-front costs. It would need to staff an underwriting team as well as an administrative body, and the cost of conducting due diligence on the initial projects would not be defrayed by the proceeds from an existing portfolio. Such a program could sustain itself over time but would likely require several years to do so, depending on the rate of project participation.

6.3 Lending Support Mechanisms

Lending support mechanisms for the exploration phase of geothermal development may be an attractive policy alternative due to the fact that nearly all exploration-phase financing in the United States comes from equity investors. Not only is equity generally more costly than debt, but the lack of lenders willing to make loans for exploration drilling and reservoir confirmation significantly limits developers' potential sources of capital at this phase. Lending support mechanisms might spur more lenders to fund geothermal projects during the exploration phase, rather than solely at the production/injection well drilling and power plant construction phases.

In the U.S. context, a lending support mechanism in the form of an interest rate subsidy could attract private lenders by providing interest payments sufficient to cover the risk of exploration drilling, while at the same time providing developers with a lower cost of capital. In contrast, government-provided loans could crowd out private investment. With direct government loans, private capital might instead flow to subsequent phases of development. To have a significant impact on project development, such a program would require substantial public funding with the possibility for losses. This puts into question the applicability of a government-provided loan program in the United States, at least at the federal level. This is especially true when considering recent concerns surrounding defaults under the DOE loan guarantee program and general concerns about fiscal prudence.

The structure of Indonesia's GFF provides an innovative example of a government direct loan program. Should U.S. policy seek to offset exploration-drilling risk faced by project developers through some sort of government loan program, a revolving loan fund may provide the most value to taxpayers when compared to other types of government loan programs, grants, and cooperative agreements. Because it is likely that 90% of U.S. geothermal resources lie on federal land (DOI 2008), the government could tender proven resources for leasing, as Indonesia does. The initial public investment in exploration drilling could then be repaid by the winning bidder from the capital they raise from private investors for subsequent phases of development. In the United States, such a fund could be managed as a national geothermal trust fund, which is a familiar concept for several other federally funded programs.

6.4 Grants and Cooperative Agreements

Grant programs directed specifically at exploration drilling reduce the amount of equity and/or debt a developer must raise from outside sources prior to the exploration phase.

The U.S. Industry-Coupled Case Studies Program, Iceland's National Energy Fund grant program, and the Japanese cost-share program all may have helped contribute to the early development of the geothermal power sector within those countries. As previously mentioned, the Industry-Coupled program in the United States resulted in the exploration of 14 sites and the construction of eight power plants, seven of which remained in operation in 2010 (Moore et al. 2010). Likewise, the Japanese cost-share program contributed to a significant increase in installed capacity in the late 1970s and early to mid-1990s. Iceland's grant program, in concert with municipal and regional government-led efforts, was a key driver of the growth of the geothermal power sector. Today, at least 22% of Iceland's total installed generation capacity is geothermal (Ragnarsson 2010). These three examples demonstrate the potential usefulness of grants and cooperative agreements adapted specifically for the exploration phase of geothermal development.

A grant or cost-share covering a portion of the exploration drilling and resource confirmation costs helps developers to mobilize outside finance before having proven the resource. Furthermore, programs, such as Japan's cost-share program, may increase the sustainability of public funding by requiring repayment of funds from successful projects or requiring winning bidders to repay the exploration costs on proven resources.

The country programs described in Section 5 highlight the fact that the impact of such programs on individual projects can depend on per-project funding levels, the structure of payments, and government capacity for funding them. An overly ambitious deadline for securing funds to match the AUD 7 million grant in the case of Australia's Geothermal Drilling Program may have impeded developers' ability to use the grant (Allen Consulting Group 2011). As a result, developers had to forfeit more than half of the grants awarded. On the other hand, the U.S. Industry-Coupled program generously covered up to 50% of exploration drilling costs (Bloomquist 2003).

Additionally, grants covering exploration activities other than drilling, such as France's feasibility study grant, may do little to address the significant exploration risk associated with drilling. But these studies may decrease the proportion of failed exploration wells as they can refine potential resource areas and nominally reduce the cost of developing projects.

Text Box 1. Drilling Tax Incentives

Geothermal power projects cannot currently take advantage of renewable energy tax incentives (e.g., the PTC and ITC) until a project is operational. Because of the long lag time between project initiation and commissioning, this creates a timing mismatch between the time when the project encounters high exploration risk and when an investor can make use of tax incentives. This mismatch hinders the ability of current U.S. renewable energy tax incentives from addressing the high risk of exploration drilling.

While not grants, tax incentives can create additional value by reducing a developer's tax liability. U.S. oil and gas investors enjoy a number of tax incentives applicable to the exploration and development phase of oil and gas projects. Among those is the option to expense or capitalize intangible drilling costs (IDCs), such as drilling time, labor, and drilling fluids. Investors in oil and gas projects can deduct up to 100% of a project's IDCs in the first year regardless of whether or not a well produces oil (Sherlock 2011). With the passage of the Energy Tax Act of 1978, Congress permitted geothermal developers to enjoy the same tax treatment. However, the business practices of applying this deduction, as well as the percentage depletion deduction, are uncertain and may warrant further research.

Those interested in creating a new capital grant program in the United States that specifically targets exploration drilling expenses may take note of Japan's cost-share program as an alternative to unrecoverable grants. As previously mentioned, Japan attempts to recover all or a portion of the government capital from successful projects in the form of a loan, while waiving repayment for unsuccessful wells. This creates a more sustainable model and higher leverage of private investment. In cases where drilling is successful, repayment of the funding with interest lessens the downside for potentially drilling dry holes. This type of "grant" could also mobilize additional private investment in geothermal power projects by limiting their exposure to only a portion of the exploration risk, in the case of a cost-share. Indeed, a study of risk mitigation strategies funded by the Geothermal Technologies Program in 2008 recommended a government co-funded drilling mechanism to provide capital for exploration drilling (Deloitte Development LLC 2008).

One potential downside is that grants are unrecoverable expenditures, and thus, unless they are "repayable" grants, the government will not recoup the funds once spent. Although the Japanese loan/grant mechanism attempts to recoup a portion of the public investment, the high failure rate of exploration drilling does not permit any grant structure to recoup capital from every funded project.

6.5 Government-Led Exploration

Government-led exploration programs can spur project development but require significant funding and have high administration costs. Also, government-led exploration may not provide much leverage in the exploration phase, as compared to other policy options. However, these types of programs may provide leverage in terms of private sector investments in later phases of development.

The research and demonstration initiatives undertaken by NEDO and AIST in Japan contributed to the early growth of the Japanese geothermal power sector. The efforts of both agencies also highlight the utility of transferring resources proven through government exploration drilling—either through a public tender, land lease, or another mechanism—to the private sector.

Likewise, Iceland's government-led development, in conjunction with the previously described grant, has resulted in substantial industry growth and project development. The unique characteristic of Iceland's government-led development is that municipal and regional governments and publically owned utilities, rather than national government entities, have undertaken nearly all of the development activities. Similar efforts could be a feasible for U.S. municipal utilities and cooperatives located in areas with good, undeveloped hydrothermal resources (or perhaps where EGS is feasible, once technology costs have come down). However, given the geographic location of most hydrothermal resources in the United States, this option is very limited in its overall potential to rapidly develop the country's resources. And with a limited rate base and requirements to make conservative investments, these typically smaller, local utilities may not find geothermal exploration economically viable.[25]

Another complicating factor for government-led development is that governments face the same risks in identifying and exploring geothermal resources as the private sector. Any expenditures that result in dry wells are sunk costs at the expense of the taxpayer. Altogether, most policy supports for the energy sector in the United States, renewable or otherwise, consist of tax incentives and/or subsidies. Unveiling a government geothermal exploration initiative would be inconsistent with recent renewable energy incentives and may not be feasible, especially in light of the fact that the U.S. geothermal market is viewed as more mature than it was in the 1970s and 1980s when the first exploration programs were implemented.

We did not include an analysis of the characteristics or applicability of Kenya's state-owned Geothermal Development Corporation or the Philippines National Oil Company Energy Development Corporation because we do not see such state-owned geothermal development entities as a viable alternative in the U.S. market. For a brief discussion of the Geothermal Development Company and Philippines state-owned energy company, see Appendices A and B.

[25] Some municipal utilities, such as the Los Angeles Department of Water and Power, which serves nearly 4 million customers, are quite large. For more information, see: https://www.ladwp.com/ladwp/faces/ladwp/aboutus/a-water/a-w-factandfigures?_adf.ctrl-state=1653rwexct_21&_afrLoop=147738510606000.

7 Key Findings and Additional Enabling Opportunities

The United States has significant, untapped hydrothermal resources. One of the main hurdles to utilizing this baseload electricity resource is the high risk of exploration drilling. Because of this risk, developers find raising capital for this phase of development particularly challenging. Even when developers are able to locate willing investors, the cost of capital can be prohibitive and is almost exclusively equity capital, which is by its very nature more expensive than debt. To address this barrier in attracting investment to the exploration phase, several countries including the United States have implemented policies intended to reduce the cost of capital or mitigate the investment risks. Our analysis has attempted to identify the policies used and comment on their characteristics and potential applicability to the United States.

The five stylized policy types initially presented in Section 4 include loan guarantees, drilling failure insurance, lending support mechanisms, grants and cooperative agreements, and government-led exploration. These policies have been implemented in a number of countries. At various times since the 1970s, the United States has implemented loan guarantees, a lending support mechanism, and grant programs in relatively straightforward manners. On the other hand, applications of all five policy types have been more nuanced when applied in other countries. In some cases, the policies were implemented in a hybridized manner, combining features of more than one policy. In Japan, for example, the government has provided loans for geothermal exploration that convert to grants if a viable resource cannot be obtained. The government-owned German development bank KfW offers a loan program for geothermal exploration in Germany that is notable for its loan-forgiveness feature that functions essentially like a loan guarantee.

Also, countries such as Iceland and the United States have provided multiple policies concurrently. In Iceland, government- or municipally owned companies undertake most of the geothermal exploration projects while the national government provides grants to support the projects. In the United States, the Industry-Coupled Case Studies program operated concurrently with the 1974 Loan Guaranty program and other incentives.

One noticeable difference between the U.S. policies and those of other countries is that the United States has not provided financing or lending support mechanisms designed specifically for the exploration phase. Although the Loans for Geothermal Reservoir Confirmation program was intended to fill this role, it was never funded. Japan, Germany, Indonesia, multilateral banks and development agencies, on the other hand, have provided loans and/or loan guarantees specifically targeted to the exploration phase. Thus far, U.S. loan guarantees have helped facilitate loans for subsequent phases of development or for the entire project cycle. This may be an area for further consideration, especially given the fact that current U.S. policies support equity investments for operational projects.

There may be room, even when considering the current U.S. policy context, for innovative policies and incentives targeted specifically to the exploration phase. The following options are theoretical and would deserve further scrutiny and research to understand their potential efficacy:

- Encourage exploration-phase financing
    - Exploration-phase loan guarantees—Current and past loan guarantees offered by the federal government covered loans for the entire project cycle. Targeting

geothermal loan guarantees to the exploration phase may encourage lenders to begin loaning money for exploration (likely on a portfolio basis), a phase currently funded almost exclusively by high cost equity.

  - Direct loan program—Although the 1980 Loans for Geothermal Reservoir Confirmation Program was never funded, authorizing and funding a new loan program specifically targeted to conventional geothermal exploration, or renewable energy projects in general, may help address the lack of debt financing currently observed in the U.S. market. Loans could either be repayable no matter the outcome of exploration drilling, or partially or fully forgivable in the case of unsuccessful drilling.. The Federal Financing Bank has already provided one loan to a geothermal project. Creating a more targeted and/or dedicated loan program, such as the Green Bank proposed in 2009, could fill in the gap left by private lenders during the exploration phase.
  - Offer a cost-share grant program for resource identification and exploration activities along the lines of the Industry-Couple Case Studies program.

- Exploration-phase tax incentives
  - Tax deduction or credit applicable to all or a subset of exploration costs—The incentives could be offered until projects reach a specific point in the development cycle. Considering the GEA's four-phase development cycle, all drilling costs up to and including the drilling of one full-sized discovery well could be considered. To avoid abuse, the incentive could be paid out in installments corresponding to defined milestones during the project development cycle. The incentives could take the form of a refundable tax credit or cash grant akin to the 1603 Treasury program.
- Expand the resource base by leveraging oil and gas drilling through co-production
  - Incentives for the assessment and/or development of geothermal resources produced as a result of oil and gas drilling—These incentives could include those mentioned above regarding exploration-phase tax incentives, or some other co-production-specific incentive to develop or collect data about co-produced geothermal fluids.

An area for future research could be to quantify the outcomes of the policy applications presented in Section 5 in order to systematically identify and analyze how many projects these policies supported in their respective countries. Such research could also determine how much public funding was required to support projects, as measured against a country's existing resource and market barriers. Except for the U.S. experience, the current analysis did not collect data at this level of detail from each country. Such research could attempt to determine, either through quantitative methods or case-study comparisons, whether policies that provide the most leverage of private investment facilitate the most rapid project development and in which contexts this may be the case. The ultimate purpose of such research would be to identify which policies maximize the goals of deployment and leverage of private investment, either concurrently or exclusively. The current state of slow growth in geothermal development demonstrates that when left to market forces alone, geothermal development will proceed slowly and sporadically.

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Appendix A. Philippines: Government-Led Exploration

The Philippines has the second-highest installed geothermal power capacity in the world with 1,998.8 MW, and its 2009–2030 National Energy Plan lays out a strategy for surpassing the United States as the world leader (BNEF 2012; Philippine DOE 2009). The GEA identified the country as having 3,500–5,730 MW of potential. It set a target of 3,447 MW in its 2009–2030 Energy Plan—a 75% increase over the country's 2009 capacity—though it has only installed approximately 27 MW since establishing its most recent target.

The renewable energy sector in the Philippines—the geothermal sector in particular—has recently undergone significant changes. Prior to 2007, government entities had conducted nearly all geothermal development activities in the country, except for the first two steam fields, developed by Chevron's Filipino precursor. In the mid-1970s the government created the Philippine National Oil Company-Energy Development Corporation (PNOC-EDC), which undertook all geothermal development projects until it was privatized in 2007 (Catigig 2008). It is now called the Energy Development Corporation. The World Bank and the Japan Bank for International Cooperation financed the majority of PNOC-EDC's geothermal development activities, providing loans for projects accounting for 1,043 MW of PNOC-EDC's 1,149 MW of installed capacity (Dolor 2005). Due to the fact that the PNOC-EDC was a government-owned company, the national government of the Philippines took all the risk associated with exploration activities.

The privatization of the PNOC-EDC, along with the market-based approach to renewable energy development laid out in the 2008 renewable energy law, will provide an interesting case study of the effectiveness of government-led geothermal development as compared to a market-based approach. However, a full analysis of the transition to a privatized geothermal sector with market-based incentives may not be possible until actual capacity additions coming online since 2007 can be compared to the plan's 2015 target of 2,382 MW.

Over the last decade, the government has opened up the geothermal power sector to competitive market forces. This has included privatization of the state-owned National Power Corporation's geothermal assets in 2001; the introduction of a bidding process for exploration projects in 2008; and the legal definition of geothermal resources as mineral resources, which has allowed entry of foreign development companies into the Filipino market. In 2011, the Philippine government approved contracts for the construction and power purchase of six new geothermal facilities.

Appendix B. Kenya: Government-Led Exploration

The Government of Kenya adopted a more innovative government-led approach to overcoming exploration-phase barriers, which had been stalling geothermal development, by creating the Geothermal Development Company, a wholly state-owned enterprise. To accelerate the previously slow geothermal project development timeframe and to reduce exploration risk, the company undertakes activities including detailed surface well exploration, infrastructure development, and drilling of exploration wells (CIF 2011). After completing exploration drilling, the company intends to tender proven resources to private investors for the subsequent development of power plants. The company's current project at the Menengai geothermal steam field aims to produce 800 MW by 2018 (GDC 2011).