The Future of U.S. Geothermal Development: Alternative Energy or Green Pipe Dream?

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ALTERNATIVE ENERGY OR GREEN PIPE DREAM?

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I. INTRODUCTION

The risks of climate change are becoming ever more apparent, and scientific consensus on the anthropogenic causes of climate change is solidifying. At the same time, support for domestic energy generation is growing. As a result, the federal government and many states have enacted policies supporting the development of alternative, renewable, lower emission domestic energy sources. These policies have helped the U.S. renewable energy industry grow at amazing rates in recent years. Solar and wind electric generating facilities, for example, are popping up across the nation, from the Mojave Desert to the Nantucket Sound. Although both solar and wind electric generating facilities provide renewable energy, neither can produce reliable baseload electric power because of their intermittent nature. In this regard, geothermal resources offer an important benefit in the development of a U.S. renewable energy portfolio.

Geothermal is undergoing a renaissance, but it is questionable whether the industry is merely experiencing a short-term boon due to favorable legislation, or is instead displaying a trend that will continue long into the future. This article attempts to address that uncertainty, assessing the long-term viability of geothermal development in the United States. The analysis begins with an overview of geothermal resource development. Property, mining, water, and environmental laws, which regulate geothermal development, will then be examined. A discussion of the many government policies that incentivize geothermal development follows. Next, economic considerations, such as market conditions, costs and risks, and competing energy sources are assessed. Finally, the article explores four critical barriers to geothermal development—policy uncertainty, high up-front costs, carbon pricing, and grid connectivity.

From this analysis it becomes clear that widely variable resource characteristics, overlapping regulatory regimes, limited financing, policy uncertainty, infrastructure limitations, and the lack of a national carbon emissions policy all inhibit the development of geothermal energy in the United States. Some of these inhibitors, such as resource characteristic variability, are rooted in technological limitations, which the U.S. Department of Energy is working to overcome. While advancing technology will bring more geothermal resources into production and lead to more efficient production from resources already in use, technological innovation will not address other factors, such as policy uncertainty, that limit geothermal industry growth.

The most substantial barrier to geothermal development lies in the state and federal legislatures, which served as the primary catalysts for recent growth. Most federal support for geothermal electricity generation is set to expire in the next few years. The federal government
and many states face crippling budget deficits, bringing policy support into question. The resulting policy uncertainty renders project costs and benefits incalculable, in turn inhibiting investors from making the long-term commitments required to discover and develop geothermal resources. Nevertheless, increasing demand for lower emission, renewable energy coupled with geothermal’s potential ubiquity and ability to provide reliable baseload electric power make the resource an appealing option for renewable energy generation in the United States. Ultimately, however, policy support—in the form of both subsidies and carbon pricing—may be the determinative factor in the future of U.S. geothermal resource utilization.

II. GEOTHERMAL ENERGY: THE BASICS

Geothermal power is resurging as a topic of discussion in conversations concerning the development of renewable energy sources. Unlike solar and wind energy, which depend on intermittent conditions to generate electricity, geothermal resources are not subject to interruption and therefore are capable of providing reliable baseload electric power. Utilizing subsurface heat, geothermal developers are producing electricity on a global scale. Some countries, such as the Philippines and Iceland, have made geothermal a primary component of their energy portfolios. Even so, the United States produces the largest quantity of geothermal electricity, though geothermal accounted for less than 1% of total U.S. electricity production as recently as 2008. Understanding where geothermal resources are located and how those resources are utilized helps to inform the analysis of the future of geothermal in the United States.

A. Location

Geothermal energy is produced from the heat contained in subsurface
reservoirs of steam, hot water, and hot dry rocks. Geothermal resources are found throughout the globe, from the Kamchatka Peninsula of Russia to the Dixie Valley of Central Nevada. At least twenty U.S. states contain federally owned geothermal resources with high potential for electricity generation. 70% of federally owned lands are considered to have a high potential for geothermal electricity generation, which translates to more than 400 million acres of potentially viable sites. The total production capacity of U.S. geothermal resources is estimated to be three million megawatts (MW) utilizing current technology, more than ten times the capacity of coal-fired power plants in the U.S. today. The potentially widespread availability of geothermal energy and its renewability make the resource an obvious choice for policymakers focused on developing domestic energy and combating climate change.

B. Utilization

Geothermal resources are utilized directly and indirectly. Direct-use applications typically involve heating and cooling, whereas indirect use normally involves electricity generation. Which use a particular resource system is susceptible to depends on the temperature of the resource: high temperature resources can be used indirectly to generate electricity, while low temperature resources can be used only directly for heating and cooling.

1. Direct Use

Low temperature resources are not presently susceptible to electricity production because current technology cannot cost-effectively drive

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10. Id. The electricity generating potential of sites is based on heat flow in units of milliwatts per meter squared. Id.


turbines with lower temperature resources. Nevertheless, lower temperature resources are frequently used for direct-use applications. For example, lower temperature, but still warm-to-hot, steam and water is increasingly used to heat buildings. Typically, water or steam is extracted from the subsurface and pumped through a continuous loop of pipes within the building, thereby providing radiant heat or cooling. The limit to direct-use application is that use is grounded in close proximity to the extraction point, because transmission over longer distances will result in unacceptable temperature changes in the extracted resource. Even in light of this limitation, direct-use geothermal heat pump production increased significantly in recent years, with total units in use nearly quadrupling from 2000 to 2009.

2. Electricity Generation

In contrast, moderate-to-high temperature geothermal resources may be used not only directly for heating and cooling, but also indirectly to generate electricity. Two methods are used to generate electricity from moderate-to-high temperature resources. First, if the resource is hot enough to produce steam from water, the steam can be extracted and used to power turbines, which drive generators to produce electricity. Alternatively, resources with temperatures that are not hot enough to produce steam can still generate electricity through a binary system, wherein extracted hot water is passed through a heat exchanger that heats a secondary fluid with a lower boiling point and higher vapor pressure than water, typically a hydrocarbon, such as isobutane or isopentane. The more volatile secondary fluid then vaporizes into

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15. Gupta & Roy, supra note 7, at 12.
17. See id. Other direct-use applications include circulating heated water or steam through pipes under roads during colder months to melt snow. See Nat’l Geothermal Collaborative, supra note 14, at 2 (discussing such a project in Klamath Falls, Oregon).
18. Gupta & Roy, supra note 7, at 205.
20. U.S. Dep’t of Energy, supra note 2, at 26; see also Gupta & Roy, supra note 7, at 12 (explaining that energy generation depends on access to high temperature resources).
steam and passes through a turbine, generating electricity.\textsuperscript{22}

As straightforward as the concept of passing steam through a turbine might seem, developing geothermal resources for electricity production is a complex, interdisciplinary venture involving seismology, geophysics, and mineral chemistry.\textsuperscript{23} Even at shallow depths, noteworthy scientific uncertainty remains, and the physics of water and rock interactions often vary greatly from one location to the next.\textsuperscript{24} Still, the basic elements of converting geothermal resources into electricity are widely agreed upon.

The energy producing capacity of a geothermal system depends on three key characteristics: heat, water, and permeability.\textsuperscript{25} While heat is present essentially everywhere below the Earth’s surface, water and permeable rock are not.\textsuperscript{26} In the early years, geothermal resource development occurred only under “ideal” conditions, where heat was close to the surface, rocks were permeable, and the subsurface formation was saturated with a recharging water source.\textsuperscript{27} Just as early oil developers went after large, easily accessible resources, so too did geothermal developers begin with the low-hanging fruit. The relative scarcity of such ideal conditions has long been a barrier to expanding geothermal energy development,\textsuperscript{28} but also a driver for technological innovation.

With the few known ideal geothermal resources already in use, developers now concentrate on resources that have at least two of the three critical conditions present.\textsuperscript{29} Since subsurface heat is ubiquitous, current research concentrates on the presence of water and permeability within a resource formation. Potentially productive formations require the enhancement of either water or permeability, or the engineering of elements already present, to achieve economic production.\textsuperscript{30} In both cases, naturally occurring systems are modified to create energy from geothermal resources deficient in economical amounts of water or permeability.\textsuperscript{31}

In a system with adequate water and heat, but insufficient

\begin{itemize}
\item \textsuperscript{22}Kutsch, \textit{supra} note 21.
\item \textsuperscript{23}Ernst Huesgen, \textit{Geothermal Energy Systems: Exploration, Development, and Utilization} 1 (2010).
\item \textsuperscript{24}Id.
\item \textsuperscript{25}U.S. Dep’t of Energy, \textit{supra} note 2, at vii.
\item \textsuperscript{26}Id.
\item \textsuperscript{27}Id. at 8–9.
\item \textsuperscript{28}Id. at 8.
\item \textsuperscript{30}Dickson & Fanelli, \textit{supra} note 21, at 9–10.
\item \textsuperscript{31}Id. at 8.
\end{itemize}
permeability, the system can be enhanced through hydraulic fracturing. Naturally hot but impermeable rock is fractured to create a reservoir and thereby allow water to flow through production wells, which funnel heated water through a heat exchange system and then reinject the water into the reservoir to be heated again. In geothermal formations possessing adequate heat and permeability, but insufficient water supplies, water is transported from a foreign source and injected into the subsurface formation.

III. REGULATORY REGIMES

Property, mining, water, environmental, tax, and public utility laws control geothermal development. However, the extent and nature of regulation of geothermal resource development depends in part on the location of the resource. Developments located on public, rather than private, lands are of course more heavily regulated, although each of the aforementioned legal regimes is often implicated even in private development. The purpose of this discussion, therefore, is to sketch out the diverse and at times overlapping regulatory systems at play in geothermal resource development, as well as some of the issues that commonly arise.

A. Property

A critical preliminary step in the development of any geothermal resource is the acquisition of the property rights needed to access the resource. Federal land grants, which are the source of title for vast quantities of western lands overlying geothermal resources, often reserved mineral rights to the federal government. Thus, when a developer is interested in geothermal resources underlying a surface grant that traces to the federal government, the developer must determine whether the original grant conveyed the mineral rights to subterranean geothermal resources. If the original grantee received

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33. Dickson & Fanelli, supra note 21, at 9–10.
34. GUPTA & ROY, supra note 7, at 9. In the West, where the most economically favorable geothermal formations exist, the relative scarcity of water is a significant factor that must be reckoned with to allow for further development. See generally Kathleen Callison, Water and Geothermal Energy Development in the Western U.S.: Real World Challenges, Regulatory Conflicts and Other Barriers, and Potential Solutions, 22 PAC. MCGEORGE GLOBAL BUS. & DEV. L.J. 301 (2010); discussion infra Parts III(C)–(D).
mineral rights, then the geothermal developer must assess whether those rights were ever severed. This can be challenging because legal characterization of geothermal resources has not always been straightforward. In early cases, for example, developers argued that geothermal resources were more like water than minerals, and were thus not reserved to the federal government. But, in many cases, the courts have resolved this uncertainty by finding that general mineral reservations include geothermal resources. However, some states, such as Washington, take the unique approach of treating geothermal resources as sui generis—neither mineral nor water resource.

Washington declares geothermal resources to be the property of the surface owner, but federal land grants reserving geothermal resources would likely supersede the state’s statutory declaration of surface estate ownership.

B. Minerals

Because geothermal resources are often treated as minerals, geothermal developments are typically subject to federal and state mining laws. For developments on federal lands, the Geothermal Steam Act controls leasing, development, and production. At the state level, regulations vary, but generally follow models similar to oil and gas development law.

The Geothermal Steam Act was enacted for the purpose of allowing exploration, development, and utilization of geothermal energy on public lands. According to this objective, the Act authorizes the Secretary of the Interior to issue leases for geothermal resource development on public lands. The Act defines geothermal resources broadly,

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36. See, e.g., United States v. Union Oil Co., 549 F.2d 1271, 1273 n.5 (9th Cir. 1977); see also Owen Olpin & Barton H. Thompson, Water Law and the Development of Geothermal Resources, 14 NAT. RESOURCES LAW. 635, 635 (1982) (noting the debate about whether or not geothermal development is a mineral or water activity and, therefore, whether state water laws apply to geothermal development).

37. See, e.g., Rosette Inc. v. United States, 277 F.3d 1222, 1228 (10th Cir. 2002); Union Oil Co., 549 F.2d at 1273–74. For purposes of state law, some state courts also treat geothermal resources as minerals. See, e.g., Pariani v. State, 105 Cal. App. 3d 923, 937 (1980); Geothermal Kinetics, Inc. v. Union Oil Co., 75 Cal. App. 3d 56, 58 (1978).

38. WASH. REV. CODE ANN. § 78.60.040 (West 2005); see also IDAHO CODE ANN. § 47-1602 (2003).

39. WASH. REV. CODE ANN. § 78.60.040.


43. 30 U.S.C. § 1002.
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encompassing all products of geothermal processes, including indigenous steam, hot water, and hot brines; hot water, hot brines, steam, and other gases resulting from the artificial introduction of fluids into geothermal formations; heat or other associated energy found in geothermal formations; and any byproduct derived from geothermal resources.\textsuperscript{44}

Leases to geothermal resources are issued for a primary term of ten years.\textsuperscript{45} If production in commercial quantities is achieved and maintained during the primary term, the lease continues for up to an additional thirty-five years as long as production continues in commercial quantities.\textsuperscript{46} If a geothermal project is still producing commercial quantities of electricity at the end of the forty-five year lease term, then the leaseholder has a preferential right to an additional forty-year lease extension, provided the land is not needed for other purposes.\textsuperscript{47} Current proposed legislation would allow developers to lease geothermal resources adjacent to an existing operation through a noncompetitive process, thereby encouraging the expansion of already producing resources.\textsuperscript{48}

C. Water

Even though geothermal resources are usually considered a mineral for ownership and development purposes, geothermal projects are nevertheless often subject to water law regimes as well.\textsuperscript{49} Geothermal resource developments frequently confront two types of water law problems. The first involves water acquisition, a relatively commonplace problem in energy development.\textsuperscript{50} The amount of water required

\begin{itemize}
\item \textsuperscript{44} Id. § 1001(c). A “byproduct” is any mineral, other than oil, hydrocarbon gas, or helium, which is found in association with geothermal resources and which (a) has a value of less than 75\% of the value of the geothermal steam, or which (b) is not, “because of quantity, quality, or technical difficulties in extraction and production, of sufficient value to warrant extraction and production by [itself].” Id. § 1001(d).
\item \textsuperscript{45} Id. § 1005(a).
\item \textsuperscript{46} Id. § 1005(g).
\item \textsuperscript{47} Id.
\item \textsuperscript{50} Olpin & Thompson, supra note 36, at 635. Acquiring water resources is a challenge for many forms of energy development. See, e.g., U.S. GOV’T ACCOUNTABILITY OFFICE, ENERGY-WATER NEXUS: A BETTER COORDINATED UNDERSTANDING OF WATER RESOURCES COULD HELP MITIGATE THE IMPACTS OF POTENTIAL OIL SHALE DEVELOPMENT (2010), available at http://www.gao.gov/new.items/d11355.pdf. However, some interesting approaches to this problem have been taken in the geothermal context. For example, a Calpine plant in Northern California utilizes treated wastewater to supply its geothermal operation. See Jane Braxton Little, Clean
depends on the type of geothermal operation, as well as the characteristics of the individual resource. For example, optimal geothermal resources are essentially self-replenishing, with water extracted, reinjected, and extracted again in a continuous loop with virtually no consumptive use.\textsuperscript{51} Other resources may lack water entirely, and thus require large quantities of water to be imported from an outside source.\textsuperscript{52} Some geothermal formations may require water not only to facilitate the subterranean heat transfer process, but also to engineer the reservoir through hydraulic fracturing.\textsuperscript{53} The quantity of water required to fracture subsurface structures, as well as the amount that will be consumed through subsurface absorption, varies based upon individual resource characteristics.\textsuperscript{54} Additionally, water is often required to facilitate cooling in the electric generation process.\textsuperscript{55}

Another water law issue involves applying water quality law to fluids—usually steam or hot water—extracted from geothermal systems. Although federal law regulates steam, hot water, brine, and any other byproduct of geothermal operations as a mineral,\textsuperscript{56} state law may regulate some of the same products under water management regimes.\textsuperscript{57} As a result, geothermal developers may be forced to deal with two separate regulatory systems governing byproducts of operation. The water in geothermal brine may be subject to state water law, while federal law will control the mineral constituents, though delineation of the two substances may not be as straightforward as the two regulatory systems suggest.

\textbf{D. Environment}

Geothermal energy is widely touted as a cleaner and more sustainable alternative to fossil fuels, but it is still subject to a host of environmental regulations. At the federal level, geothermal projects frequently undergo environmental impact analysis under the National Environmental Policy


\textsuperscript{51} See Callison, \textit{supra} note 34, at 305. Ormat's facility near Reno, Nevada withdraws 44,000 gallons of geothermal brine per minute and reinjects nearly 99\% of that amount to be used again. \textit{Id.}

\textsuperscript{52} See \textit{supra} note 34 and accompanying text.

\textsuperscript{53} See \textit{supra} note 32 and accompanying text.

\textsuperscript{54} Hydraulic fracturing typically requires significant quantities of water. For example, one geothermal fracturing experiment expected to use as much as 1,000,000 gallons of water for each fracture stimulation. See Press Release, \textit{supra} note 32. Such considerable quantities of water may be difficult to obtain in the arid West, where the most optimal geothermal resources are located. Notably, the challenge of acquiring water for hydraulic fracturing is also a hurdle for extraction of fossil fuels, particularly shale gas.


\textsuperscript{56} 30 U.S.C. § 1001(c) (2006).

\textsuperscript{57} Callison, \textit{supra} note 34, at 308.
Act (NEPA), especially when development is taking place on federally owned lands.\textsuperscript{58} However, NEPA analysis for some aspects of geothermal development has been streamlined,\textsuperscript{59} and recently introduced legislation would exempt geothermal test wells from the NEPA process altogether.\textsuperscript{60}

Geothermal resource projects on public lands are also subject to a multiple-use land planning mandate under the Geothermal Steam Act, which requires that geothermal developments coexist with other land uses.\textsuperscript{61} As a result, the development of geothermal resources on public lands may not reach full potential where other conflicting land uses exist. Geothermal projects can also run into problems with the Endangered Species Act where utilization of subsurface water resources threatens critical habitat.\textsuperscript{62}

Moreover, geothermal developments could fall within the regulatory scope of the Clean Water Act. For example, where produced brines are not completely reinjected, but instead discharged to evaporation ponds, geothermal developers could be forced to obtain a pollution discharge permit under Section 404 of the Clean Water Act if the development is located in close proximity to surface waters.\textsuperscript{63}

The Safe Drinking Water Act, which protects drinking water sources, including groundwater, regulates geothermal developments through the underground injection control program (UIC).\textsuperscript{64} The UIC prohibits the pollution of underground drinking water sources through injection wells.\textsuperscript{65} Geothermal injection wells are assigned to the least regulated UIC category, known as “Class V” wells,\textsuperscript{66} though more stringent regulations will apply to geothermal injection wells that are found to


\textsuperscript{61} 30 U.S.C. § 1016.

\textsuperscript{62} See, e.g., Dale Goble, A Fish Tale: A Small Fish, the ESA, and Our Shared Future, 40 ENVTL. L. 339, 344 n.40 (2010) (discussing how geothermal exploration threatened to adversely affect protected habitat).


\textsuperscript{64} 40 C.F.R. §§ 144–148 (2011).

\textsuperscript{65} Id. § 144.12(a).

\textsuperscript{66} Id. §§ 144.6(c), 144.81(11).
present a risk of contaminating subsurface drinking water sources.67

Ironically, however, the 2005 Energy Policy Act modified the Safe Drinking Water Act definition of “underground injection” to exclude hydraulic fracturing,68 which creates an odd situation for geothermal developers: reinjection of naturally occurring fluids extracted from subterranean structures is regulated under UIC, but injection of foreign chemicals used in the fracturing process is not.

IV. DEVELOPMENT INCENTIVES

The recent growth in the geothermal sector can largely be attributed to changes in federal, state, and local law encouraging the development of renewable energy in general and geothermal energy in particular.69 These laws and policies include direct incentives like tax abatements, credits and deductions, loan guarantees, and grants, which have helped to attract private capital to geothermal development.70 Indirect incentives, such as renewable energy portfolio standards, also drive geothermal development by influencing the behavior of electric service providers, which in turn affects electricity producers. Other, nonlegal conditions, including rising fossil fuel costs, also encourage geothermal development.

A. Tax Benefits

Numerous tax abatements, credits, and deductions are provided for direct geothermal use and for geothermal electricity generation. At the state level, property and sales and use tax abatements are frequently available, and in some jurisdictions refundable tax credits can be obtained. However, most state tax incentives are relatively discretionary, often attaching financially significant strings to a project’s ability to generate local economic benefits. Federal tax law also incentivizes geothermal development through tax credits and deductions.

67. Id. §§ 144.12(c)–(d). The remote location of many geothermal resources limits the risk of regulation under this section of the UIC. However, the growing search for urban water supplies may bring more and more geothermal resources within the purview of this aspect of the UIC. See, e.g., Matt Jenkins, Vegas Forges Ahead on Pipeline Plan: Great Basin Pumping Project Is Closer to Reality, HIGH COUNTRY NEWS (Colorado), Oct. 12, 2009, available at http://www.hcn.org/issues/41.17/vegas-forges-ahead-on-pipeline-plan.


69. For an insightful preliminary reference on geothermal development incentives, see the DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY, http://www.dsireusa.org/ (last visited Oct. 17, 2010).

1. Abatements

To spur geothermal development, many states abate property and sales and use taxes for geothermal electricity projects. State tax abatements are typically discretionary and require applicants to meet eligibility requirements, such as minimum production capacity and demonstrated economic benefits to the jurisdiction. But, state tax abatements for geothermal developments vary considerably in the quantity and quality of eligibility requirements, the amount of abatements awarded, and the types of expenditures eligible for abatement.

For example, California, Nevada, and Utah administer geothermal tax abatement programs. In Utah, abatement of all state and local taxes is possible, whereas in Nevada, property and sales and use taxes may only be partially abated, and in California, only sales and use taxes may be abated. Under each program, a geothermal resource developer must apply to a state agency for tax abatement. Application eligibility requirements often include a minimum electricity generation capacity, which varies in amount from one state to another, as well as demonstrated economic benefits to the jurisdiction awarding the abatement. Nevada even goes so far as to require abatement recipients to employ a certain number of full-time employees, a portion of whom must be Nevada residents; pay an hourly wage that is a specified amount higher than the statewide average hourly wage; make capital investments of a specified amount in Nevada; and provide construction workers with health insurance, including the option of dependent coverage.

74. The agencies responsible for administering geothermal tax abatements in the aforementioned states are as follows: in Utah, the Governor’s Office of Economic Development; in Nevada, the Director of the State Office of Energy; and in California, the California Alternative Energy and Advanced Transportation Financing Authority. See DATABASE OF STATE INCENTIVES FOR RENEWABLES & EFFICIENCY, supra note 69.
75. In Nevada, for example, property and sales and use tax abatements are available only to projects with a minimum electricity generation capacity of 10 MW, Nev. Rev. Stat. § 701A.320(1)(b), though developments generating as little as 10 kW were previously eligible. Similarly, Utah requires facilities to be able to generate at least 20 kW of electricity in order to be eligible for sales and use tax abatements. UTAH CODE ANN. § 59-12-104. California, in contrast, does not impose a minimum generation capacity requirement.
76. California requires economic benefits of the geothermal project to the state, as well as other conditions, to be considered as factors in assessing an application for abatement. Cal. Pub. Res. Code §§ 26011.8(d)(3), (5) (West 2010) (requiring consideration of number of new permanent jobs created and current unemployment in area of development).
The benefits of abatement also vary among the states. In California, geothermal developers may receive a total abatement of sales and use taxes. The same is true in Utah, where eligible projects may receive a total abatement of not only sales and use taxes, but all state and local taxes. The incentives in Nevada are not quite so generous, with geothermal projects eligible for a 55% reduction of property taxes for up to twenty years. Nevada also offers a reduction in the sales and use tax, which ranges from 6.85% in rural counties to 8.1% in metropolitan areas, to an abated rate of 2.6% from July 2011 through June 2049.

The types of expenditures eligible for tax abatements also vary from state to state. Utah takes a narrow view of the class of expenditures eligible for sales and use tax abatement, listing specific abatable expenditures, while California allows abatement for virtually all costs associated with geothermal resource development. Nevada, Utah, and California allow abatements for expansions, though Utah makes eligible only expansions of 1 MW or more in generation capacity. Nevada, in contrast, makes eligible all property used to generate electricity from renewable energy sources.
2. Credits

Tax credits are available under both state and federal programs. Utah, for example, provides a refundable tax credit\textsuperscript{88} for both direct geothermal use and geothermal electricity generation.\textsuperscript{89} The Utah credit is available to systems supplying electricity to a commercial unit, as well as those engaged in the sales of electricity.\textsuperscript{90} For electricity generation systems with less than 660 kilowatts (kW) of total generation capacity, the Utah credit equals 10% of reasonable system installation costs up to $50,000.\textsuperscript{91} For systems capable of generating in excess of 660 kW, the credit is $0.35/kilowatt-hour (kWh) for four years.\textsuperscript{92} However, the credit may not be carried forward or back.\textsuperscript{93}

Federal tax credits for geothermal resource development are also available. The Business Energy Investment Tax Credit can provide geothermal developers a corporate tax credit equal to 10% of expenditures, with no maximum credit limit.\textsuperscript{94} The Renewable Electricity Production Tax Credit provides corporate tax credits equal to $0.022/kWh of electricity generated from qualified resources, including geothermal, and sold by the taxpayer to an unrelated person during the taxable year.\textsuperscript{95}

3. Deductions

In addition to state and federal tax credits and state tax abatements, geothermal projects are eligible for federal tax deductions under the Modified Accelerated Cost-Recovery System, which creates a corporate
depreciation deduction for geothermal property investments, thereby helping to defray the high front-end costs of geothermal development. Qualified projects acquired and placed into service after September 8, 2010 and before January 1, 2012 may deduct 100% of the adjusted basis of the property during the tax year the property is placed into service. For eligible projects placed in service during 2012, 50% of the adjusted basis may be deducted during the tax year 2012. The actual benefit of this deduction depends, however, on the size of the recipient’s taxable income.

B. Direct Payments

Qualified geothermal projects may receive direct payments from several federal programs. In lieu of production tax credits, geothermal electricity producers can elect to receive a Treasury Department grant equal to 30% of the basis of the project’s value, though the benefit is available only to projects that commenced construction by December 31, 2011. In the case of direct use, geothermal heat pumps are eligible for a Treasury Department grant equal to 10% of the basis of the heat pump property.

On top of that, agricultural producers and rural businesses are eligible for grants up to 25% of the cost of geothermal direct use and electricity projects under the U.S. Department of Agriculture’s Rural Energy for America Program (REAP). Established in 2003 and renewed in the 2008 Food, Conservation, and Energy Act (also known as the Farm Bill), REAP has awarded more than $281 million in grants, including $50 million in 2010. But, REAP is up for reauthorization in 2012 and fiscal pressures make its future uncertain, though the Obama

97. See infra notes 185–88 and accompanying text.
100. Tax Relief, Unemployment Insurance Reauthorization, and Job Creation Act § 401, 124 Stat. at 3304.
administration and others are lobbying lawmakers to maintain funding for REAP.106

C. Loan Guarantees

Loan guarantees are another policy approach to encouraging geothermal development. The guarantees come in the form of both government bonds and loan insurance. The Internal Revenue Service administers tax incentives deriving from two different bond programs—Clean Renewable Energy Bonds (CREBs) and Qualified Energy Conservation Bonds (QECBs)—that subsidize geothermal project financing through the use of qualified tax credit bonds.107 The two programs, which provide bond purchasers with tax credits rather than interest payments, are authorized to provide up to $3.2 billion in bond issues.108 However, CREBs and QECBs are generally available only to public entities, and to date no bonds have been issued for geothermal projects.109

The Department of Energy administers a more broadly applicable loan guarantee program, authorized for up to $10 billion in guarantees, for projects that “(1) avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gases; and (2) employ new or significantly improved technologies as compared to commercial technologies in service in the United States at the time the guarantee is issued.”110 Such loan guarantees have helped to finance at least three U.S. geothermal projects.111 However, the recent bankruptcy of

106. Peterka, supra note 104.


Solyndra, the beneficiary of a $535 million Department of Energy guaranteed loan, has brought the loan guarantee program into disrepute in some circles.112

D. Renewable Portfolio Standards

States also indirectly encourage geothermal resource development through renewable energy portfolio standards (RPSs).113 These standards typically require electric utilities to derive a certain percentage of electricity sold from renewable resources. On average, RPSs lead to retail electricity rate increases of less than 1%.114 Nevada, which provides a typical example of a RPS, requires its electric service providers to generate a minimum percentage of electricity sold from renewable resources like geothermal,115 with an RPS goal of roughly 20% by 2025.116 Nevada’s RPS also provides for a portfolio energy credit (PEC) trading program, where PECs are awarded based on kilowatt-hours generated from renewable energy.117 Those PECs may be “banked,” or saved for later trading or use.118

California, on the other hand, does not have a credit-trading program, but it does mandate relatively aggressive standards. Established in 2002, California’s RPS requires investor-owned electricity producers to increase the percentage of their sales from renewable sources annually, with a goal of achieving 20% renewable electricity generation by December 31, 2010.119 It appears, however, that the 2010 goal was not met, with California’s investor-owned utilities—Pacific Gas & Electric Co., Southern California Edison, and San Diego Gas & Electric Co.—achieving 18% renewable generation at the end of 2010.120

An executive order issued by Governor Schwarzenegger and approved

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113. For an insightful discussion of state RPS, as well as an argument for a national RPS, see Lincoln L. Davies, Power Forward: The Argument for a National RPS, 42 CONN. L. REV. 1339 (2010).
116. Id. § 704.7821(1)(h).
by the California Air Resources Board expands California’s RPS goals, declaring a goal of 33% renewable portfolios by 2020 and subjecting all electric utilities, including publicly owned municipal utilities, to the standards.\textsuperscript{121} The legislature adopted this goal in 2011.\textsuperscript{122} Given the increasing demand in California for renewably generated electricity, renewable electricity producers in nearby states, such as Nevada, will likely find growing opportunities to sell renewably generated electricity to California service providers trying to meet increasing RPS responsibilities.\textsuperscript{123}

Utah, in contrast to California and Nevada, takes a more lax approach to RPSs. Rather than require electric utilities to produce certain percentages of electricity sold from renewable energy, Utah asks electricity providers to pursue renewable energy only to the extent it is cost-effective.\textsuperscript{124} And, unlike most states with RPSs, Utah provides no interim goals, only an end goal of 20% renewable generation by 2025.\textsuperscript{125} However, Utah law requires utilities to file progress reports every five years,\textsuperscript{126} while also providing for a renewable energy certificate trading program.\textsuperscript{127} Yet, without a renewable portfolio mandate, Utah electricity generators have little incentive to create and trade renewable energy certificates.\textsuperscript{128}

\textbf{E. Fossil Fuel Costs}

In both direct use and electricity generation, geothermal competes with fossil fuels, such as coal, natural gas, and oil. While fossil fuels have long been less costly than geothermal energy, assuming environmental and other externalized costs are not considered,\textsuperscript{129} decreasing fossil fuel

\textsuperscript{124} \textsc{Utah Code Ann.} § 54-17-602(1)(a) (LexisNexis 2010).
\textsuperscript{125} Id.
\textsuperscript{126} Id. § 54-17-604(2)(a).
\textsuperscript{127} Id. §§ 54-17-602(4), 54-17-603. However, the lack of a strong RPS mandate and the wide discretion Utah law provides utilities in assessing whether to pursue renewable electricity generation likely diminishes the value of tradable certificates, thereby rendering the trading program ineffective.
\textsuperscript{128} Utah also provides a clear example of how state definitions of what qualifies as “renewable” for RPS complicate the regulatory field. See \textsc{Utah Code Ann.} § 54-17-601(10)(a)(vi) (defining renewable energy sources to include natural gas from certain coal operations); see also Davies, \textit{supra} note 113, at 1357 (asserting that definitional variations among state RPSs complicate the regulatory framework).
\textsuperscript{129} See infra notes 175–82 and accompanying text.
supplies and increasing discovery and extraction costs are making geothermal more competitive.\textsuperscript{130} For example, the production of oil, which is frequently used for home heating purposes and sometimes for electricity generation,\textsuperscript{131} likely reached its apex in 2006.\textsuperscript{132} In light of increasing global demand, declining production will result in increased prices, making alternative energy sources such as geothermal more attractive.\textsuperscript{133}

Even in the absence of increased fossil fuel costs that are likely to come, one recent investment bank study found the average cost of geothermal electricity generation was less than the average cost of coal electricity generation.\textsuperscript{134} The study found further that geothermal remained competitive with coal even without tax incentives.\textsuperscript{135}

\section*{V. Market Conditions}

In 2006, a Massachusetts Institute of Technology research panel published a report asserting that given adequate funding, 100,000 MW electric of geothermal could be developed within the next fifty years.\textsuperscript{136} Congress and the energy sector took note, and growth in the geothermal sector soon followed with what has been described as a “renaissance.”\textsuperscript{137} From 2006 to 2008, the number of U.S. geothermal projects doubled.\textsuperscript{138} In the words of one report, “2008 was a watershed year for the

\begin{thebibliography}{138}
\bibitem{130} See Christopher Mims, \textit{Can Geothermal Power Compete with Coal on Price?}, SCI. AM. (Mar. 2, 2009), http://www.scientificamerican.com/article.cfm?id=can-geothermal-power-compete-with-coal-on-price (discussing the viability of geothermal power considering the decreased cost of conventional energy sources such as fossil fuels).
\bibitem{133} According to the U.S. Energy Information Administration, fossil fuel costs increased an average of 6.9\% from 2009 to 2010: coal costs increased 1.8\%, natural gas costs increased 7.2\%, and petroleum costs increased 36.3\%. See U.S. ENERGY INFO. ADMIN., ELECTRIC POWER MONTHLY 2 (Sept. 2011), available at http://205.254.135.24/electricity/monthly/.
\bibitem{134} See LAZARD, LEVELIZED COST OF ENERGY ANALYSIS 2 (2009), available at http://www.cleanenergy.org/images/factsheets/Lazard2009_LevelizedCostofEnergy.pdf. The average cost of geothermal electricity generation ranged from $58 to $93 per MWh, while the average cost of coal-generated electricity ranged from $78 to $144 per MWh. \textit{Id.; see also U.S. DEP’T OF ENERGY, GUIDE TO PURCHASING GREEN POWER 7 (2010), available at http://www.epa.gov/greenpower/documents/purchasing_guide_for_web.pdf.}
\bibitem{135} LAZARD, \textit{supra} note 134, at 6 (finding that the average cost of geothermal electricity production in the absence of tax incentives ranged from $85 to $120 per MWh).
\bibitem{137} CROSS & FREEMAN, \textit{supra} note 29, at 4.
\end{thebibliography}
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2008 also saw the unveiling of the U.S. Department of Energy’s Geothermal Technologies Program (GTP), which in its inaugural year awarded more than $43 million in geothermal research grants to academic institutions and private enterprises. At the same time, the U.S. Department of Interior’s Bureau of Land Management increased the amount of federal land available for geothermal exploration and development, while also streamlining the permitting and leasing processes. Philanthropic donations also played a significant role in driving geothermal market growth in 2008, with Google’s charity doling out more than $10 million in research and development grants.

The geothermal sector has continued to experience unprecedented investment growth over the last several years, largely due to a favorable policy arena. The United States is the global leader in installed geothermal capacity, and U.S. projects receive the majority of global geothermal investment. While geothermal remains a resource of enormous potential, it is largely undeveloped. Geothermal receives only a miniscule fraction of total renewable energy investment, contributes less than 1% of U.S. electricity production, and employs approximately one-tenth the workforce that the solar and wind industries do.

The post-2006 boom in geothermal development saw tremendous

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139. CROSS & FREEMAN, supra note 29, at 1.
140. Id. at 2, 9–11. Congressional funding for GTP increased by at least 46% in each of the last three years. Id. at 5, Table 1.
141. Id. at 1. As of 2008, more than 300,000 acres under BLM control were leased for geothermal exploration and development. Id. at 2.
142. Id. Two private enterprises—AltaRock Energy and Potter Drilling—were respectively awarded $6 million for EGS research and $4 million to advance drilling technology. Id. at 7. Google.org awarded an additional $500,000 grant to the Southern Methodist University Geothermal Laboratory for research on improving geothermal resource assessment techniques. See Knapp, supra note 12.
143. Id. at 4.
144. DELOITTE DEVELOPMENT L.L.C., supra note 138, at 2. The present policy focus on developing clean and independent energy sources is of critical importance to geothermal development. See id. at 4.
145. CROSS & FREEMAN, supra note 29, at 12.
146. Id. at 5–6.
147. DELOITTE DEVELOPMENT L.L.C., supra note 138, at 4. In 2007, geothermal received only 1% of the $100 billion invested in renewable energy. Id. at 2.
148. Id.
149. CROSS & FREEMAN, supra note 29, at 12. However, geothermal accounts for more than 12% of U.S. renewable energy production, excluding hydropower. Id.
150. MARK MUBRO ET AL., BROOKINGS INST., SIZING THE CLEAN ECONOMY: A NATIONAL AND REGIONAL GREEN JOBS ASSESSMENT 20 (2011), available at http://www.brookings.edu/~media/Files/Programs/Metro/clean_economy/0713_clean_economy.pdf. Still, from 2003 to 2010 the geothermal industry experienced 7% average annual job growth. Id. at 22, Table 2. Notably, this period coincides with the USDA’s rural energy program. See supra notes 102–06 and accompanying text.
growth in the number of actors in the geothermal market.\textsuperscript{151} The roster includes many major players, including vertically integrated developers and suppliers such as U.S. Geothermal, Ormat, Chevron, and Calpine, as well as specialized service providers that focus on particular aspects of development, such as exploration, drilling, confirmation, engineering, and construction.\textsuperscript{152} However, most new players are relatively small enterprises that are particularly susceptible to the effects of shrinking capital markets.\textsuperscript{153} The 2008 collapse of the financial markets thus had substantial impacts on geothermal development.\textsuperscript{154}

Geothermal developers are heavily dependent on equity markets and monetizing production tax credits to obtain financing.\textsuperscript{155} The economic collapse limited purchase demand for tax credits, as institutional investors like Morgan Stanley, GE Capital, and the now bankrupt Lehman Brothers, which previously purchased production tax credits and provided geothermal capital, were left with little resources to invest.\textsuperscript{156} Of the fourteen finance companies that funded renewable energy development, including geothermal, in the last decade, only half are still in business today.\textsuperscript{157} A prime example, Glitnir Bank, an Icelandic financier that was highly active in geothermal project finance, was nationalized in 2008 and has almost entirely disappeared from geothermal finance.\textsuperscript{158}

Nevertheless, the economic downturn did bring some positive changes to geothermal economics. For example, the price of steel, which is a core component of geothermal development, fell almost 30\% in the fourth quarter of 2008.\textsuperscript{159} Similarly, construction costs also dropped considerably following the recession, due in part to the drop in competing demand for construction services.\textsuperscript{160}

VI. Barriers to Development

Policy uncertainty, the lack of carbon pricing, a front-loaded
investment profile, and transmission limitations are aggravating the challenges already facing geothermal resource utilization. The failure of Congress to implement a national carbon pricing system dramatically inhibits geothermal development by maintaining an uneven playing field, where a key advantage of geothermal energy—reduced carbon emissions—is not accounted for. Even after surmounting this threshold hurdle, geothermal developers still face a challenging, front-loaded investment risk profile, which limits private investment.

On the policy front, Congress has provided only short-term assurances to developers dependent on long-term support to achieve economic viability. Geothermal resources require many years to locate, develop, and produce economically, and short-term congressional support thus provides only limited incentive for development. Projects able to take advantage of favorable policies still face the considerable problem of connecting to the electricity transmission grid. Gaining approval for transmission projects can take many years and add substantial costs to geothermal resource development.

A. Policy Uncertainty

Doubt about whether policies supporting renewable energy will continue is perhaps the single greatest factor inhibiting geothermal resource development. Unlike conventional energy sources, for which continued policy support is all but guaranteed, renewable energy resources, such as geothermal, have been subject to the ebbs and flows of politics. Proposed federal legislation would eliminate essentially all federal policy support, rendering the future of U.S. geothermal energy uncertain. Because policy uncertainty raises doubts about geothermal project economic viability, investment growth is inhibited.

In recent years, the federal renewable production tax credit (PTC) has been “the single most important program supporting renewable [electricity] generation.” The program provides a tax credit for each

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161. Cf. MURO ET AL., supra note 150, at 34 (“[T]he fact that significant policy uncertainties are likely depressing investment in the clean economy reinforces the need for engagement and reform.”).


kilowatt-hour of renewable electricity produced, and the credit can be claimed for up to ten years.\textsuperscript{165} To take advantage of the PTC and to create an important source of project capital, geothermal developers have utilized a special purpose entity known as a partnership flip.\textsuperscript{166}

Only an owner and operator of a renewable electricity project may claim the PTC,\textsuperscript{167} but most developers do not have sufficient tax liabilities to take advantage of the credit.\textsuperscript{168} To take advantage of the PTC and address the need for project capital, developers pair with large institutional investors who are able to take advantage of the tax credit. A partnership is formed with a disproportionate allocation of project income and loss to the institutional investor seeking the PTC benefit, until an agreed upon after-tax return on investment is realized, which typically occurs after the expiration of the ten-year PTC term.\textsuperscript{169} At that point, the investor’s ownership percentage is reduced, and the project “flips” back to the developer. Thus, the total benefits accrued to the investor over the ten-year term, including tax benefits like the PTC as well as electricity sales revenues, creates a present cash value for the project that helps geothermal development move through critical financing stages.

Prior to implementation of the PTC, geothermal electricity production was growing at a rate of approximately 15\% per year.\textsuperscript{170} In the two years following the implementation of the PTC, the number of U.S. geothermal projects nearly doubled.\textsuperscript{171} However, the PTC was originally implemented for only a two-year period, and each renewal has been for similarly short durations.\textsuperscript{172} As a result, short-term renewable energy projects like wind and solar have benefited most from the PTC.\textsuperscript{173} Geothermal development, which in comparison to other renewable resource developments is a long-term project, has accordingly suffered from the short-term uncertainty of the PTC. The present PTC for geothermal applies to geothermal projects placed in service by the end of 2013. Legislation proposed by Congressmen Labrador and Pompeo would eliminate the PTC.\textsuperscript{174} Thus, the prospects for long-term policy support of geothermal development remain in doubt, especially given

\begin{itemize}
\item \textsuperscript{165} 26 U.S.C. § 45 (2006).
\item \textsuperscript{166} CROSS & FREEMAN, supra note 29, at 22–23.
\item \textsuperscript{167} 26 U.S.C. § 45.
\item \textsuperscript{168} CROSS & FREEMAN, supra note 29, at 23.
\item \textsuperscript{169} Id.
\item \textsuperscript{170} DELOITTE DEVELOPMENT L.L.C., supra note 138, at 9.
\item \textsuperscript{171} Id.
\item \textsuperscript{173} Id. at 10.
\item \textsuperscript{174} Barker, supra note 163.
\end{itemize}
present federal fiscal constraints.

B. Carbon Pricing

The lack of a national carbon pricing system greatly limits the extent to which U.S. geothermal resources are developed. Carbon pricing has the potential to be perhaps the most powerful driver of geothermal development, because geothermal energy production emits far less carbon than the fossil fuels that presently supply the majority of U.S. electricity. Although some states have implemented carbon pricing systems, Congress has thus far failed to achieve a consensus on how to reign in the externalities of carbon emissions on a national scale. This failure, in turn, inhibits the development of geothermal and other lower emission energy supplies, which stand at a competitive disadvantage with fossil fuels so long as carbon emission costs are not considered. Coal, which accounts for roughly half of the electricity generated in the United States, is responsible for approximately 20% of global greenhouse gas emissions.

That Congress has been reluctant to impose carbon pricing while at the same time enthusiastically doling out energy subsidies demonstrates a democratic preference for handouts over taxes. The preference is

175. A recent Brookings Institution report identified the lack of carbon pricing as one of the most significant barriers to the “clean” economy. See MURO ET AL., supra note 150, at 34; see also Roberta F. Mann, Federal, State, and Local Tax Policies for Climate Change: Coordination or Cross-Purpose?, 15 LEWIS & CLARK L. REV. 369, 372 (2011) (“A consistent price signal at the federal level could encourage an energy shift to renewable sources . . . .”).


179. For example, American Electric Power recently shelved plans for a carbon sequestration project because Congress has failed to implement carbon pricing. See Katie Fehrenbacher, AEP to Ditch Carbon Capture, Clean Coal Plan, REUTERS (July 14, 2011, 12:49 AM), http://www.reuters.com/article/2011/07/14/idUS292146858620110714.


181. Mann, supra note 175, at 381.
unsurprising, but costly, because subsidies may not always be the most efficient way to guide energy development.\textsuperscript{182}

\textit{C. High Up-Front Costs}

Geothermal development is also significantly inhibited by a front-loaded investment profile. Geothermal projects proceed through several steps—identification, exploration, drilling, and production—and the types and amounts of costs and risks vary at each stage.\textsuperscript{183} For example, developing a 50 MW geothermal electricity generation facility will, on average, cost $1 million to identify resources, $9 million to explore resources, $15 million to drill wells, and $60 million to construct the facility.\textsuperscript{184}

The challenge for geothermal resource developers is to assess the economic viability of subsurface resources,\textsuperscript{185} which requires substantial investments in identifying and exploring the resource before the potential profitability of exploiting the resource can be known. In the aforementioned example, a developer would have to spend $10 million before even knowing whether a resource could produce profitably.

Given the high risk that a project may not be profitable, traditional lending institutions generally refuse to finance the early stages of geothermal development, even though identification and exploration represent only a small portion of total development costs.\textsuperscript{186} This “steep, front-loaded risk profile” makes obtaining project-wide financing essentially impossible, and different stages of geothermal projects are accordingly financed by different sources.\textsuperscript{187} Prior to proving feasibility of a geothermal resource, essentially all capital comes from the equity markets.\textsuperscript{188}

The high-risk, front-loaded cost of geothermal projects creates two problems for developers. The first is a money gap: developers must obtain adequate capital to confirm viable resources before being able to

\textsuperscript{182} Id. (discussing ethanol subsidies); see also Pierce, supra note 176, at 298 (arguing that “[s]ubsidies for carbon-free domestic fuels are extremely expensive, largely ineffective, and ultimately unsustainable”).

\textsuperscript{183} See Deloitte Development L.L.C., supra note 138, at 15.

\textsuperscript{184} Id.; see also Cross & Freeman, supra note 29, at 19. It should be noted that “cost and risk increase proportionately with drilling depth.” Id. at 21.


\textsuperscript{186} Deloitte Development L.L.C., supra note 138, at 19.

\textsuperscript{187} Cross & Freeman, supra note 29, at 1, 20–21. Risk declines as a geothermal project moves closer to production, making later development stages better suited to conventional bank financing. Id. at 21.

\textsuperscript{188} Id. at 22; see also Deloitte Development L.L.C., supra note 138, at 19.
move into later development stages where more traditional financing becomes available.\footnote{DELOITTE DEVELOPMENT L.L.C., supra note 138, at 19.} The second and corollary problem is the lack of any mechanism for sharing the risks associated with early steps in the development process.\footnote{Id.} Since equity capital is the only option for financing early development, risk is inevitably concentrated in a small number of investors. As a result, the combination of the money gap and the lack of a risk-sharing mechanism leads to the need for extremely high investment returns to justify the proportionate investment risk.\footnote{Id.}

\section*{D. Infrastructure Limitations}

A fourth critical obstacle to growth in geothermal energy utilization is found in the electricity transmission grid. U.S. infrastructure for transmitting electricity is a patchwork of independently owned power plants and transmission lines of varying age and condition.\footnote{For a helpful primer on U.S. electricity transmission, see Visualizing the U.S. Electric Grid, NAT'L PUB. RADIO (Apr. 24, 2009), http://www.npr.org/templates/story/story.php?storyId=110997398.} Geothermal electricity projects, the location of which in no way correlates to transmission line location, must nevertheless connect to the grid to deliver produced electricity. Connecting to transmission lines, however, can require tremendous efforts. The connection lines will almost inevitably cross public land and public opposition is all but guaranteed. To avoid crippling litigation, legislation supporting transmission line connections “will be extremely helpful, if not necessary.”\footnote{Lincoln Davies, And Now for Some Good News?, ENVTL. L. PROF BLOG (June 24, 2011), http://lawprofessors.typepad.com/environmental_law/2011/06/and-now-for-some-good-news.html.}

The contentious San Diego Gas and Electric (SDG&E) Sunrise Powerlink project exemplifies just how challenging it can be to connect geothermal electricity projects to end users. The 117-mile, $1.9 billion high voltage Sunrise line would connect San Diego to the resources of the Imperial Valley, which SDG&E’s chairman described as “the most productive renewable energy fields in the world.”\footnote{Matthew L. Wald, Power Line Project Faces Challenges in California Valley, N.Y. TIMES, Nov. 28, 2010, at A30, available at http://www.nytimes.com/2010/11/28/science/earth/28transmission.html?src=twrhp.} The line would only be capable of carrying a portion of the estimated 8,500 MW renewable production capacity of the Imperial Valley,\footnote{Eric Wolff, Energy: Powerline Could Give SDG&E Commanding Position, N. COUNTY TIMES (Escondido), Dec. 12, 2010, available at http://www.nctimes.com/business/article_b22ffe05-4e0e-52ca-8fd2-7a8e852d3e13.html.} but it would nevertheless add a substantial renewable energy supply to a major metropolitan
SDG&E has thus far spent seven years and $100 million trying to break ground on the Sunrise Powerlink. California’s Renewable Energy Transmission Initiative supported the project, and SDG&E filed an 11,000-page environmental impact statement that won the approval of state and federal regulators. Nevertheless, citizen groups mounted opposition to the Sunrise project and sued to challenge regulatory approvals. To date, opposition to the transmission line has managed to prevent the project from moving forward.

VII. CONCLUSION

At least in theory, the utilization of geothermal energy is relatively straightforward: heat transfers from rocks to water, creating steam that drives turbines, which in turn generate electricity. In practice, that seemingly simple process turns out to be quite complicated. The heat, porosity, and water content of subsurface geologic structures vary widely, thereby creating a development process that is front loaded with risks and costs at the early stages of exploration and discovery. As a result, geothermal developers must rely primarily on the economically depressed capital markets for financing early development. Uncertainty over whether policy will continue to support geothermal development makes it difficult to finance projects, because investment recovery periods grow substantially in lieu of policy incentives.

Even in light of these obstacles, the special ability of geothermal to provide clean, reliable baseload electric power cannot be ignored. Other nations have already demonstrated the potential for geothermal in the domestic energy portfolio. In the Philippines, for example, more than 20% of electricity is generated from geothermal energy. Similarly, Iceland derives large percentages of electricity and heating energy from geothermal.

From an economic standpoint, geothermal technologies have worldwide application and therefore offer lucrative export opportunities that could provide an additional return on investment for the U.S. geothermal industry. Recent years have seen an explosion of

196. Id.
197. Wald, supra note 194.
199. Wald, supra note 194.
200. Id.
201. Geothermal Basics: Current Use, supra note 3. Similarly, Iceland derives large percentages of electricity and heating energy from geothermal. Id.
202. For this reason, the U.S. Secretary of Commerce recently launched a renewable export initiative, headed by a geothermal industry leader. Secretary of Commerce Launches National
geothermal development in Kenya, for example, where the government has awarded millions of dollars in contracts to foreign corporations and continued growth is expected.203 Even bigger opportunities are on the horizon, as India is poised for $169 billion of investment in clean energy, including geothermal.204

For a number of reasons the United States has thus far been the locus of geothermal research and development. First and perhaps foremost, U.S. research institutions are extremely well equipped to address the complex, interdisciplinary problems that arise in geothermal development. Furthermore, U.S. policy has been highly influential in fostering industry growth. But, the United States’ continued leadership in geothermal energy development is not a given. China is investing heavily in geothermal technology, a fact evidenced by Chinese companies’ dominance of development in Kenya, to the detriment of the U.S. competition.205 The question, thus, is not whether the geothermal industry will be economically viable over the long term, but rather whether it will be the United States that leads the innovation and derives the economic benefit. The answer to that question will remain uncertain until Congress makes a long-term commitment to developing renewable energy and reducing carbon emissions.

