



Geothermal Brief: Market and Policy Impacts Update

Bethany Speer

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-6A20-53288
October 2012

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Introduction

Utility-scale geothermal electricity generation plants have generally taken advantage of various government initiatives designed to stimulate private investment. This report investigates these initiatives to evaluate their impact on the associated cost of energy and the development of geothermal electric generating capacity using conventional hydrothermal technologies.

We use the Cost of Renewable Energy Spreadsheet Tool (CREST) to analyze the effects of tax incentives on project economics. Incentives include the production tax credit (PTC), U.S. Department of Treasury (Treasury) cash grant, the investment tax credit (ITC), and accelerated depreciation schedules.^{1,2} The second half of the report discusses the impact of the U.S. Department of Energy's (DOE) Loan Guarantee Program on geothermal electric project deployment and possible reasons for a lack of guarantees for geothermal projects. For comparison, we examine the effectiveness of the 1970's DOE drilling support programs, including the original loan guarantee and industry-coupled cost share programs.

¹ Access versions of CREST to analyze geothermal electric projects as well as solar (photovoltaics and concentrated solar power) at <http://financere.nrel.gov/finance/content/CREST-model>.

² State and local incentives and programs designed to support geothermal projects are outside the scope of this analysis. For more information on state and local programs, see the Database of State Incentives for Renewables and Efficiency (DSIRE): <http://www.dsireusa.org>.

Current Installed Capacity and Planned Development

Globally, installed geothermal electric capacity is approximately 11.2 GW as of May 2012 (GEA 2012a). The United States has the largest market share with 3.2 GW of operational power from 78 hydrothermal plants as of April 2012 (Islandsbanki 2011; GEA 2012c).^{3,4} As shown in Figure 1, most geothermal capacity and plants are located in California (over 2.6 GW from 48 plants) and Nevada (473 MW from 21 plants) (GEA 2012b). Alaska, Hawaii, Idaho, Oregon, Utah, Wyoming, and New Mexico also have operating hydrothermal plants.

The United States has significant development potential with 9.1 GW of identified resources, and there are estimates of an additional 30 GW of undiscovered resources (Islandsbanki 2011). As shown in Figure 2, approximately 130 U.S. geothermal projects are in development. These projects include a combination of conventional hydrothermal (greenfield and expansion)⁵ and unspecified resource projects (GEA 2011b).⁶ Nearly half of the projects in development are in Nevada, with additional projects in California, Oregon, Utah, Idaho, Alaska, Hawaii, New Mexico, Colorado, Arizona, and Washington.⁷ However, most projects are in the earliest stages of development, and few plants are close to construction.⁸

³ The Islandsbanki installed capacity data is based on information reported by each country at the April 2010 World Geothermal Congress in Bali, Indonesia.

⁴ According to the Department of Energy's Geothermal Technologies Program website, "The natural hydrothermal resource is ultimately dependent on the coincidence of substantial amounts of heat, fluids, and permeability in reservoirs, and the present state of knowledge suggests that this coincidence is not commonplace in the earth. An alternative to dependence on naturally occurring hydrothermal reservoirs involves human intervention to engineer hydrothermal reservoirs in hot rocks for commercial use. This alternative is known as Enhanced Geothermal Systems (EGS)." For additional information, see http://www1.eere.energy.gov/geothermal/enhanced_systems.html.

⁵ A greenfield area is a location where geothermal resources have not been proven or developed. Expansion sites are located near known geothermal resources.

⁶ Unspecified plants could include enhanced geothermal systems (EGS), geo-pressured resources, and co-production, as well as the development of conventional hydrothermal greenfields and expansions (GEA 2011b).

⁷ GEA notes additional projects are in development in Texas, Louisiana, North Dakota, and Wyoming—these plants are not included in Figure 2 as the locations were not available from SNL.

⁸ Phase 1 consists of having identified the resource, secured rights to a resource, finished pre-drilling exploration, and completed internal transmission analysis (GEA 2011b). In Phase 2, the developer has "Exploration and/or drilling permits approved, exploration drilling conducted/in progress, and transmission feasibility studies underway." In Phase 3, developers are "Securing PPA and final permits, have drilled full size wells, secured financing for a portion of project construction, and have completed the interconnection feasibility study." Phase 4 is where "the plant permit has been approved, the facility is under construction, the production and injection drilling are underway, and the interconnection agreement has been signed."

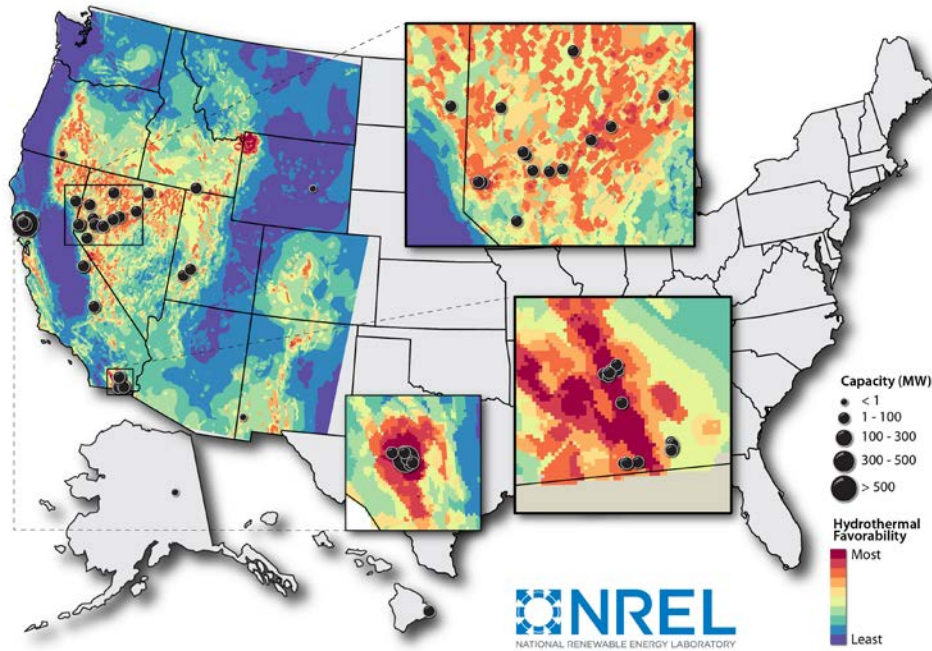


Figure 1. Operating hydrothermal plants of the United States by capacity
 Operating plant data source: SNL Energy 2012; Hydrothermal favorability data source: US Geological Survey; Map author: Billy J. Roberts, September 10, 2012

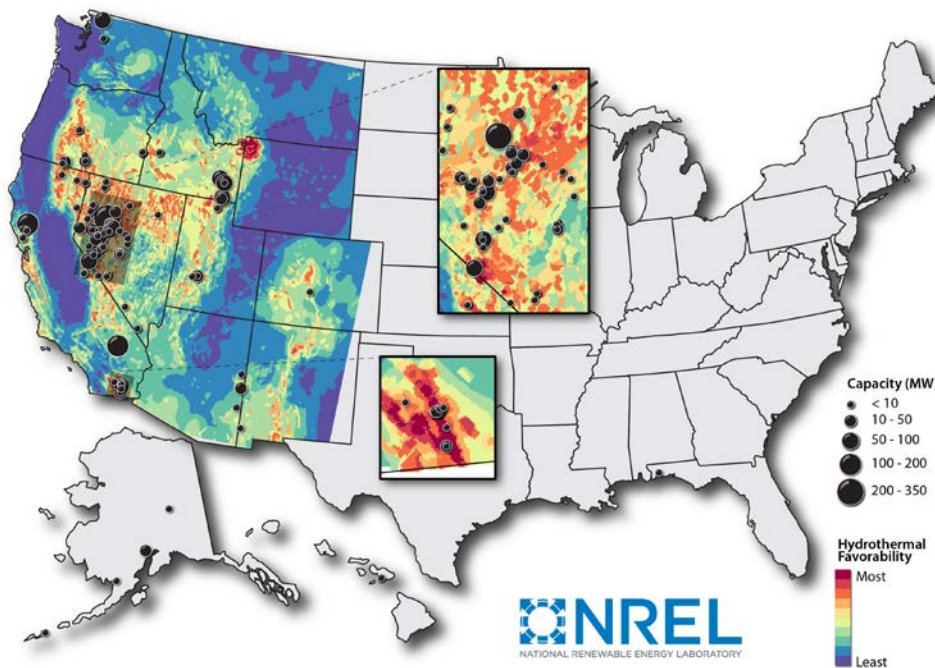


Figure 2. Hydrothermal plants of the United States currently in development by capacity
 Developing plant data source: SNL Energy 2012; Hydrothermal favorability data source: US Geological Survey; Map author: Billy J. Roberts, September 10, 2012

According to the Geothermal Energy Association, total project development has remained nearly flat from 2010 through Q1 2012. In 2010, 5,386 MW were in development; in 2011, 5,423 MW were in development (GEA 2011a)⁹; and as of Q1 2012, there is approximately 4,882 MW to 5,366 MW in development, including unconfirmed projects (GEA 2012c).¹⁰ One geothermal plant came online in 2010: a 15-MW plant in Jersey Valley, Nevada, developed by Ormat Technologies (GEA 2011a). Five additional projects came online from 2011 through Q1 2012, three of which were expansions of existing projects (GEA 2012c). In addition to barriers directly related to project economics, the lack of market growth could be due to a number of factors, including policy uncertainty, inability to gain access to capital, permitting challenges, unavailability of drilling platforms, and/or lack of tax-equity investors (Salmon et al. 2011).

⁹ GEA significantly changed how it collected data for 2011, making comparisons with earlier years difficult.

¹⁰ Confirmed projects in development total between approximately 4,116 MW to 4,525 MW (GEA 2012c).

Current Federal Geothermal Financial Incentives

Geothermal projects have been eligible for a variety of federal tax incentives and loan guarantees, two of which expired in 2011, and there are four others that will expire by the end of 2013 (see Figure 3). Federal tax incentives provide a valuable benefit to geothermal plant investors by either reducing the upfront system costs or providing an ongoing revenue stream. To make efficient use of tax incentives, developers often form partnerships with equity investors who have the tax liability to monetize potentially significant tax credits and deductions.¹¹ Alternatively, a loan guarantee can help reduce the cost of financing capital expenditures by lowering the borrower's default risk and therefore improving loan terms. Either incentive type can improve the ability of project developers, lenders, and investors to install plants while earning a rate of return that sustains their interest in the industry.

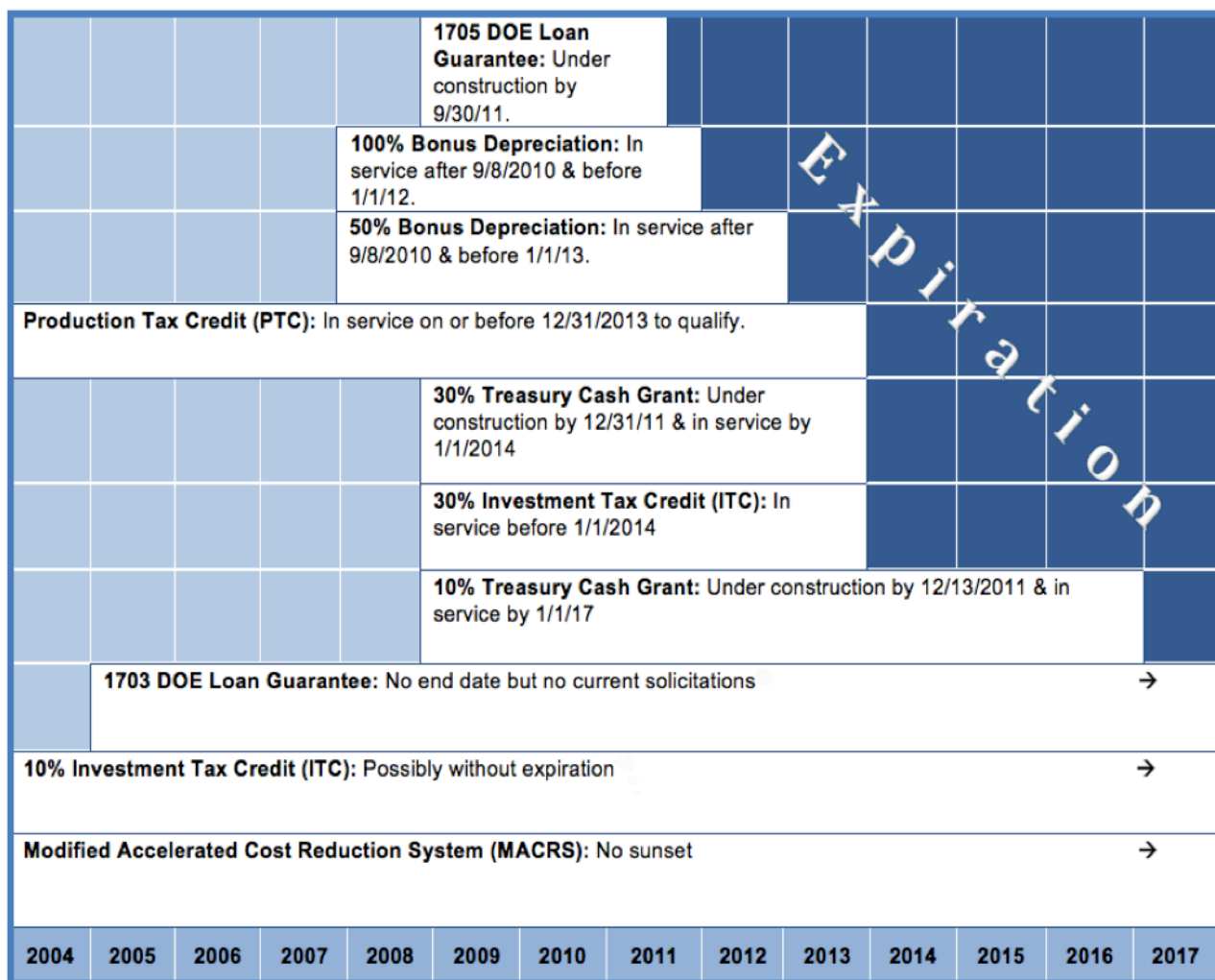


Figure 3. Timeline of federal geothermal financial incentives

Source: NREL; Adapted primarily from Salmon et al. 2011; Feldman 2011; DSIRE 2011a

¹¹ For more information on geothermal project finance, see the *Guidebook to Geothermal Power Finance* at <http://www.nrel.gov/docs/fy11osti/49391.pdf>.

Federal Tax Credits and Grants

The federal government offers two main types of tax incentives for renewable energy projects, including for geothermal electric plants: accelerated depreciation schedules and tax credits/grants.¹² A tax attorney can determine a project's eligibility for these incentives.

The 5-year modified accelerated cost recovery system (MACRS) is an advanced asset depreciation schedule that applies to a range of property classes appropriated for business use; it does not exclusively cover renewable energy assets and it does not sunset. After the economic downturn in 2007 and 2008, the federal government made provisions for bonus depreciation that allowed businesses to deduct 50% of depreciation in the first year a qualifying property was placed in service. This was further modified in 2010 under the American Recovery and Reinvestment Act to allow for 100% first-year depreciation for property placed in service between September 8, 2010, and January 1, 2012 (DSIRE 2011b). As of this writing, the 100% year-one bonus depreciation has expired, but the 50% year-one bonus depreciation is available until the end of 2013.¹³

Qualifying projects also have access to one of the following federal tax incentives:

1. **PTC of \$0.015/kWh in 1993-dollars indexed for inflation** (currently \$0.022/kWh) and claimed at the end of each of the first 10 years of production for projects placed in service on or before December 31, 2013
2. **ITC for up to 30%** of the eligible tax basis for projects placed in service before January 1, 2014¹⁴
3. **Treasury cash grant of up to 30%** of the eligible tax basis in lieu of the 30% ITC; to qualify for the Treasury cash grant, projects must have begun construction or incurred over 5% of project costs by December 31, 2011, and must be placed in service by January 1, 2014¹⁵
4. **ITC of up to 10%** of the eligible tax basis for projects through 2016 and possibly without expiration¹⁶
5. **Treasury cash grant of up to 10%** of the eligible tax basis in lieu of the 10% ITC for projects that were under construction by December 31, 2011, and will be in service by January 1, 2017.

¹² For additional information and resources, including eligible costs, relevant legislation, and history of the incentives, see DSIRE's pages on the following:

MACRS and Bonus Depreciation: http://dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06F;

Treasury Cash Grants: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US53F;

Investment Tax Credits: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US02F&re=1&ee=0; and
Production Tax Credits: http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US13F&re=1&ee=0.

¹³ In the first year, the 50% bonus depreciation is taken. The remaining 50% of the eligible costs are depreciated at the applicable MACRS schedule over the remaining timeframe.

¹⁴ The use of the ITC reduces the depreciable tax basis by 15%, whereas there is no reduction in the depreciation basis with the PTC (Bolinger et al. 2009).

¹⁵ As with the ITC, use of the Treasury cash grant reduces the depreciable basis by 15% whereas the PTC does not. (Bolinger et al. 2009)

¹⁶ There is uncertainty about whether there may be an expiration date with the 10% ITC beyond December 31, 2016.

Modeling Methodology

The leveled cost of energy (LCOE) is a calculation of the “minimum revenue per unit of production needed for the modeled renewable energy project to meet its equity investors’ assumed minimum rate of return” (Gifford and Grace 2009-2011). The specifics of LCOE calculations vary and can include or exclude incentives. Comparing LCOEs of projects (hypothetical or actual) can provide understanding into what drives project economics. For example, combinations of accelerated depreciation schedules and tax incentives/grants impact a project’s LCOE to varying degrees.

The following analysis uses the geothermal version 1.2 of CREST to demonstrate the effect of incentive choices on the LCOE when debt is optimized for the maximum allowable amount for a given incentive combination based on limitations with CREST.^{17,18} CREST is a suite of economic cash-flow models developed by NREL and collaborators to assess projects, design cost-based incentives, and evaluate the impact of tax incentives or other support structures. CREST was developed and reviewed by industry experts and NREL analysts through careful examination of cell logic and result comparisons with other market-tested LCOE calculation tools. Versions for geothermal electric as well as wind and solar (photovoltaic and concentrated power) can be accessed at <http://financere.nrel.gov/finance/content/CREST-model>.

Unless modified, all CREST input values are defaults and are held constant to measure the impact of incentive choices on the LCOE. The only non-tax incentive default input that was altered was the after-tax internal rate of return (IRR), which was increased from 12% to 15%. The debt-to-equity ratio was optimized by increasing the percentage of debt to just below the point at which the debt service coverage ratio (DSCR) “fails.”¹⁹ By optimizing the debt, it is possible to see how much a project could feasibly borrow with a given choice of incentives. Debt is less expensive than equity, so developers are likely to optimize debt with the purpose of either (1) reducing the cost of capital and increasing project returns while keeping the same electricity contract price or (2) reducing the electricity contract price, and thus allow for a more competitive bid.²⁰ Eleven incentive cases plus the base case were analyzed using different variable combinations. For example, the PTC + 100% Bonus case assumes the project took the PTC and 100% bonus depreciation with all other variables held constant.

Analysis

All 11 cases reduced the LCOE from the base case. Although the base case debt is set at a constant 50%, a developer would likely optimize the debt in all incentive situations. This was done to allow for a constant against which the value of the incentives and optimized debt in the other scenarios could be measured in terms of a reduction in the LCOE. CREST assumes that federal tax incentives

¹⁷ For a more detailed description of LCOE and the methodology and assumptions applied in CREST, see the geothermal CREST model at http://financere.nrel.gov/finance/files/content/CREST/NREL_CREST_Geothermal_version1.2.xlsx.

¹⁸ This analysis builds off of the Lawrence Berkeley National Laboratory/National Renewable Energy Laboratory report, *PTC, ITC, or Cash Grant? An Analysis of the Choice Facing Renewable Power Projects in the United States* that includes background information on the history and use of federal tax incentives. The report can be found at <http://eetd.lbl.gov/ea/emp/reports/lbnl-1642e.pdf>.

¹⁹ CREST has built in “checks” for the minimum DSCR that are based on recent conversations with industry to help users ensure that their assumptions regarding project-level debt fall within reasonable ranges.

²⁰ In CREST, the default rate for the Target After-Tax Equity Internal Rate of Return (IRR) is 12% (although it was raised to 15% for this analysis) and 7% for the Interest Rate on Term Debt. While actual market target IRRs and interest rates will vary, the difference (8%) illustrates the disparity in the costs of equity and debt.

cannot be used towards debt obligations and instead applies the benefits towards return on equity.²¹ This is an assumption intended to reflect the practice of many banks that do not lend against the ITC, PTC, or depreciation (although exceptions could occur).²² Very high incentive levels may cause the default DSCR requirements to “fail” if modifications to the default values are not made and cash flows remain insufficient. In other words, the greater the incentive level, the lower the amount of cash flow available to cover debt payments.

As the highlighted row in Table 1 indicates, the PTC +100% Bonus Depreciation case provides the greatest value to a geothermal project in terms of lowering the LCOE. It should be noted, however, that this combination is currently not possible as the provision for 100% bonus depreciation expired at the end of 2011.

Production Tax Credit

The PTC offers several benefits relative to the ITC:

- Geothermal projects have a high capacity factor and therefore can potentially derive more value from the PTC—payment of which is based on kilowatt-hours generated—as compared to the ITC, which applies to roughly 75% of installed costs (Bolinger et al. 2009).
- The year-one tax credit provided by the PTC is lower than that of the ITC (which is received in one lump sum), thereby allowing for the involvement of a larger pool of tax equity investors with lower tax liabilities.
- The PTC may allow for a more liquid investment compared to a project using the ITC. The ITC is vested to the project owner over the first 5 years of operation and is subject to a 5-year claw-back requirement. Thus, a buyer would not be able to take advantage of any remaining years of the ITC during the 5-year claw-back period when the ITC is vested to the initial owner.²³ In contrast, a buyer of a project using the PTC can monetize any remaining years of the tax credit as there is no claw-back with the PTC (e.g., if the project is sold in year three, the buyer can monetize the PTC for the remaining 7 years) (Bolinger et al. 2009).

Using the PTC, however, can be challenging:

- The project must be fully in service by the end of 2013 to receive the PTC for the first 10 years of operation.

²¹ Note that federal tax incentives are utilized in the LCOE calculation, however.

²² Projects likely could have taken out debt against the 30% Treasury cash grant. This is because the cash grant was received 60 days after a complete and eligible application was filed to the Treasury and was not dependent on tax liability. The timing of the cash grant payment reduced the risk that the cash grant would not be received and improved the ability to access debt against the cash grant. However, CREST treats the ITC and cash grant identically for simplicity.

²³ During the first 5 years of the project, it must remain with one owner or otherwise the ITC is subject to partial claw-back by the Treasury, which would reduce the value of the ITC.

- Using the PTC may be riskier compared to taking either the ITC or the Treasury cash grant²⁴ as the amount of the PTC received is dependent upon two unknowns:
 - The project's energy production
 - The tax equity investor's ability to maintain a large enough tax liability to absorb the PTC over the first 10 years of the project's operation (Bolinger et al. 2009).
- The PTC may not secure as low of a cost of capital compared to the Treasury cash grant or ITC due to higher perceived risk (Bolinger et al. 2009).
- The PTC requires the owner to operate the project, thereby ruling out the option of a lease, which is feasible with the Treasury cash grant and ITC.²⁵

²⁴ The 30% Treasury cash grant is no longer available as of the end of 2011, except for projects that are already under construction or that have met safe harbor rules.

²⁵ Sale-leasebacks, in which the developer sells the project to the tax equity investor and leases it back, have only recently been applied to geothermal projects. One known example is the Dixie Valley project developed by Terra Gen: <http://www.greenenergyreporter.com/renewables/geothermal/terragen-closes-286m-leaseback/>.

Table 1. LCOE Analysis of Federal Tax Benefits with Optimized Debt/Equity Ratios

Variables			Outcomes	
Tax Credit/Grant	Depreciation	Optimized Debt	Nominal LCOE (\$/kWh)	Reduction in LCOE from Base Case
Base Case	MACRS	50% Debt/ Not Optimized	\$0.1092/kWh	NA
PTC	100% Bonus	37%	\$0.0668	39%
	50% Bonus	45%	\$0.0719	34%
	MACRS	54%	\$0.0761	30%
30% Grant	100% Bonus	56%	\$0.0771	29%
	50% Bonus	63%	\$0.0813	26%
	MACRS	71%	\$0.0854	22%
30% ITC	100% Bonus	56%	\$0.0771	29%
	50% Bonus	63%	\$0.0813	26%
	MACRS	71%	\$0.0854	22%
10% Grant	MACRS	82%	\$0.0927	15%
10% ITC	MACRS	82%	\$0.0927	15%

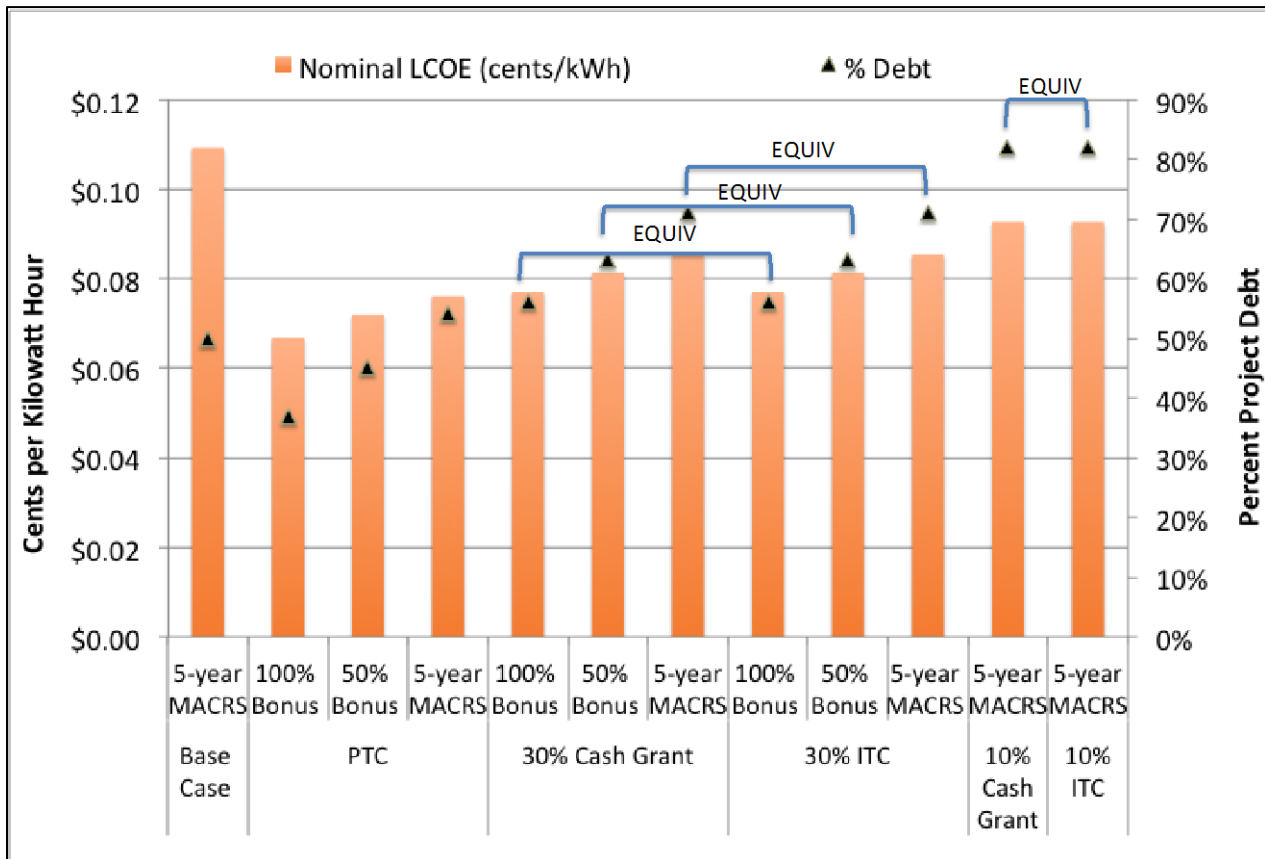


Figure 4. LCOE analysis of tax incentives with optimized debt/equity ratios

Investment Tax Credit and Treasury Cash Grant

Based on CREST assumptions and analysis, the 30% ITC and the 30% Treasury cash grant have an equivalent impact on LCOE. However, some developers, investors, and lenders may have a preference for the cash grant payment to the tax credit. This is because the tax credit requires taxable income and may have to be carried forward over multiple tax years by smaller developers who lack the tax appetite to absorb the tax credit in year one.²⁶ In contrast, the cash grant required no taxable income, thus reducing the project's risk. In addition, the cash grant was received in a shorter timeframe than the ITC (or PTC), and therefore it may have had a larger present value due to the time value of money (Bolinger et al. 2009; Mendelsohn 2010a).²⁷ And with a cash grant, if the developer was able make use of MACRS or the bonus depreciations (or the project was able to forgo using accelerated depreciation altogether), it may not have needed to involve tax equity investors.

Table 2 lists geothermal projects that have received Treasury cash grants as of October 2012. Thus far, 15 grants have been issued with amounts ranging from just over \$5,000 to more than \$108 million. The two smaller issuances were for projects located in the Northeast, and all of the larger projects are in the western states of California, Nevada, and Utah with the exception of one project in Hawaii. Lists of projects that have received the PTC or ITC are not available.

Table 2. Recipient Geothermal Projects of Treasury Cash Grants

Award Date	Business	Property Location	Amount Approved
9/21/09	Enel Salt Wells, LLC	Nevada	\$21,196,478
9/21/09	Enel Stillwater, LLC	Nevada	\$40,324,394
12/28/09	Solutions In Human Resources, Inc	Pennsylvania	\$5,071
2/16/10	Thermo No. 1 BE-01, LLC	Utah	\$32,990,089
6/21/10	Shalmuk Investors, LLC	Connecticut	\$6,142
8/17/10	ORNI 18 LLC	California	\$108,285,626
7/6/11	NGP Blue Mountain I LLC	Nevada	\$65,741,725
10/5/11	Beowawe Binary, LLC	Nevada	\$1,679,932
2/29/12	AMOR IX, LLC	Nevada	\$2,112,178
3/21/12	Geysers Power Co., LLC	California	\$12,203,772
3/29/12	CPN Wild Horse Geothermal, LLC	California	\$3,743,320
4/14/12	Puna Geothermal Venture	Hawaii	\$13,821,143
5/11/12	ORNI 15 LLC	Nevada	\$34,608,728
6/5/12	ORNI 42 LLC	Nevada	\$23,822,345
6/21/12	Hudson Ranch Power I LLC	California	\$102,086,944
Total Grants Issued to Geothermal:		\$462,627,887	
Total Grants Issued to All Technologies:			\$14,040,817,766

Source: Treasury 2012

²⁶ Carrying tax credits forward reduces their value as it is uncertain whether the developer will have the tax appetite to make use of the tax credits in subsequent years and because of the time value of money.

²⁷ The cash grant is received from the U.S. Treasury Department within 60 days of the grant application date or the date the property is placed in service, whichever is later (DSIRE 2011c). The ITC is deducted from the next tax year's filing.

The LCOE analysis was repeated for the same 12 cases with the debt-to-equity ratio held constant, using the CREST default value of 50% and a loan tenor of 15 years. As with the previous analysis, all combinations of incentives were shown to reduce the nominal LCOE when compared to the base case, as shown in Table 3 and Figure 5.²⁸

Importantly, the PTC + 100% Bonus and the PTC + 50% Bonus cases did not pass the DSCR requirements of a minimum annual ratio of 1.2 and an average ratio of 1.45, despite providing the theoretical highest value to a project in terms of lowering the LCOE.²⁹ Typically, banks would require the DSCRs to be met for the project to secure financing. Different incentive combinations may result in the inability to meet DSCR because CREST seeks to solve for the target after-tax IRR.³⁰ Because the PTC is not applied toward repaying debt, but rather flows toward the return on equity, the cash available to service the debt principal and interest payments may fall below the minimum or average DSCR target in specific years, or over the duration of the loan term. The implication is that a project developer using the PTC + 100% Bonus or PTC + 50% Bonus combinations could potentially face difficulties taking on as much debt compared to using other incentive combinations.³¹ Potential solutions to passing the DSCR, using current assumptions, include only taking MACRS with the PTC (and not the 50% bonus depreciation), reducing the amount of debt, lengthening the loan tenor, lowering the DSCR, or lowering the target IRR, among other possibilities.

²⁸ A nominal LCOE does not discount for inflation, whereas a real LCOE does account for the time value of money and negates inflationary impacts.

²⁹ As shown in the Lawrence Berkeley National Laboratory (LBNL) report, *PTC, ITC, or Cash Grant?*, the PTC provides more value in nearly all cost and capacity factor combinations tested in that analysis because the 30% ITC is assumed to apply to 75% of the installed costs, whereas the PTC is not restricted to a certain percentage of installed costs (Bolinger et al. 2009). Also, geothermal projects typically have very high capacity factors (e.g., 85% to 90%), thereby allowing projects to earn significant production-based tax credits.

³⁰ It is possible to only use equity to fund a plant development or to adjust down the amount of debt. However, some developers prefer to use debt to minimize the cost of capital. Therefore lenders would require a minimum DSCR of close to 1.2 for commercial technologies with high numbers of installed projects, and usually higher for emerging technologies or new installations of proven technologies (without many recent installations).

³¹ This analysis relies on the specific calculations and defaults included in the CREST model. Therefore, actual financial modeling results and implications will vary depending on the financial model used, the assumptions applied, and specific lender requirements.

Table 3. LCOE Analysis of Federal Tax Benefits at 50% Debt and 15-Year Loan Tenor

Variables		Nominal LCOE (\$/kWh)	Reduction in LCOE from Base Case
Tax Credit/Grant	Accelerated Depreciation		
Base Case	MACRS	\$0.1092	NA
PTC	100% Bonus	FAILS DSCR – adjust debt ratio, loan tenor, DSCR, target IRR, etc., to pass min. DSCR	NA
	50% Bonus	FAILS DSCR – adjust debt ratio, loan tenor, DSCR, target IRR, etc. to pass min. DSCR.	NA
	MACRS	\$0.0782	28%
30% Grant	100% Bonus	\$0.0782	28%
	50% Bonus	\$0.0854	22%
	MACRS	\$0.0947	15%
30% ITC	100% Bonus	\$0.0782	28%
	50% Bonus	\$0.0854	22%
	MACRS	\$0.0947	15%
10% Grant	MACRS	\$0.1030	6%
10% ITC	MACRS	\$0.1030	6%

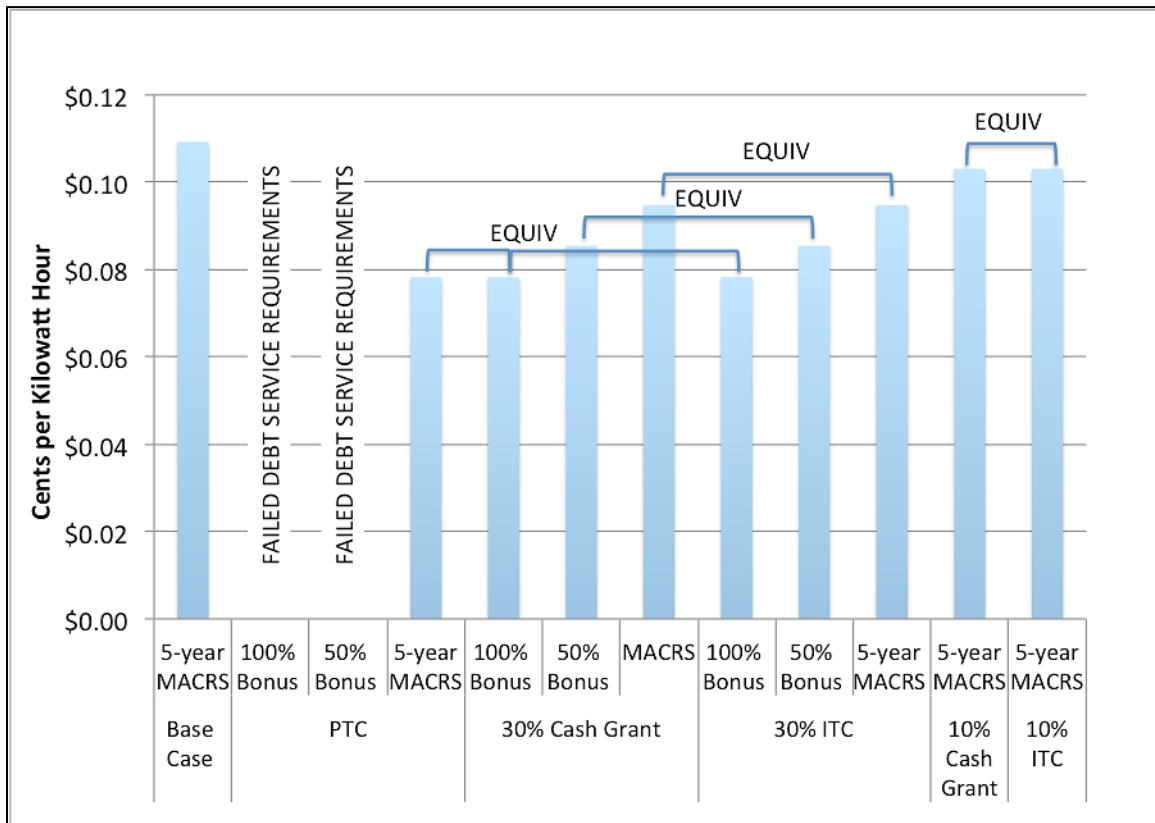


Figure 5. Nominal LCOE analysis of tax incentives with 50% debt and a 15-year loan tenor

After the PTC and ITC expire at the end of 2013, geothermal projects can apply to use the 10% Treasury cash grant for projects under construction by year-end 2011 and placed in service before 2017.³² Geothermal projects appear to have indefinite access to the 10% ITC and MACRS through at least 2016.³³ However, as shown in this analysis, the 10% Treasury Cash Grant + MACRS and the 10% ITC + MACRS incentive combinations provide much less value than the other currently available incentives, reducing the cost of energy by only 6% relative to the base case (i.e., MACRS only). The most valuable incentive combinations currently available (e.g., PTC + MACRS) reduced the first-year cost of energy by 28%.

A comparison of Table 1 with Table 3 highlights the impact of optimizing the debt, where the LCOE for each case is comparatively lower with optimized debt. For example, the LCOE for the PTC + MACRS at 50% debt is \$0.0782/kWh compared to a slightly lower \$0.0761/kWh with optimized debt.

Federal Loan Guarantees

The Federal Loan Guarantee Program was initiated under Section 1703 of Title XVII of the *Energy Policy Act of 2005* to ensure the repayment of innovative clean technology (including geothermal electric) project debt in the event of a default. The 2009 passage of the *American Reinvestment and Security Act* amended Title XVII with Section 1705, which provides loan guarantees to approved commercialized renewable energy projects and manufacturers (DOE “1705”). As part of the 1705 program, applicants had the option to participate in the Financial Institution Partnership Program (FIPP), under which the private market conducts most of the project due diligence and handles many aspects of the loan application (Mendelsohn 2010b).

Although the 1703 program has authority to support \$1.5 billion of project-level debt for renewable energy projects, none have received loans thus far (Feldman 2011). In contrast, the 1705 program has supported \$16.4 billion in loans for renewable energy generation and manufacturing and transmission projects as of the closing of the program on September 30, 2011.

³² To qualify for the PTC, projects must be in service on or before December 31, 2013. Projects must be in service before January 1, 2014, to qualify for the 30% ITC. For the 30% Treasury cash grant, projects must have already met the safe harbor requirements by December 31, 2011, and be placed in service by January 1, 2014.

³³ There is uncertainty about whether there may be an expiration date with the 10% ITC; a tax expert should be consulted.

Table 4. Geothermal Project Recipients of Federal Loan Guarantees

Project(s)	Developer	Lender	Program	Amount	Capacity	Issued
Blue Mountain	Nevada Geothermal Power Co.	John Hancock	1705, FIPP	\$99 MM - closed	36 MW	9/2010
Neal Hot Spring	U.S. Geothermal	Federal Financing Bank	1705, Not FIPP	\$97 MM - closed	23 MW	2/2011
McGinness, Jersey Valley, Tuscarora	Ormat Nevada	John Hancock	1705, FIPP	\$350 MM (conditional)	121 MW	6/2011
RETRACTED Wister, CD-4, Dead Horse Wells	Ormat Nevada	John Hancock	1705, FIPP	\$330 MM	80 to 90 MW	NA
Total Loan Support: \$545 million (Not including retraction)						

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

Only three geothermal projects have received loan guarantees—all under the 1705 program—for a total of just over \$545 million in loan support for nearly 180 MW of installed capacity (Feldman 2011).³⁴ In contrast, nearly \$13.5 billion in 1705 loan guarantees were awarded to solar photovoltaic and concentrated generation projects and manufacturing plants. Thus, geothermal (along with several other technologies, such as biofuels and wind) received a comparatively small portion of the total amount of supported loans.³⁵ Because the Loan Program Office does not release information on all applicants or declined loan guarantees, the total number of geothermal applicants is unknown.

One reason cited by a developer for not participating in the loan guarantee program is the transaction costs. In 2010, after having been offered a loan guarantee, Ormat Nevada Inc. announced it would not proceed with Part II of the application for up to \$330 million in loan support for its Wister, CD-4, and Dead Horse Wells plants (Ormat 2010a). Ormat specifically cited transaction costs along with uncertainties related to the permitting process as the impetus for the retraction. However, as indicated in Table 4, Ormat went forward with loan guarantees for its Jersey Valley, McGinness Hills, and Tuscarora projects in Nevada under a separate application.

Another possible reason for a lack of geothermal loan guarantees is disinterest by lenders to participate in the loan guarantee program. As shown in Table 4, John Hancock Financial Services is the only private lender to have participated in FIPP. The only other financier to have lent to geothermal projects under the non-FIPP portion of the 1705 program is the Federal Financial Bank, which is a government corporation under the advisory of the Secretary of Treasury (Treasury 2011).

³⁴ For additional information on Federal loan guarantees for geothermal projects, see <http://financere.nrel.gov/finance/content/breaking-new-ground-geothermal-projects-secure-federal-loan-guarantees>.

³⁵ Wind projects received \$1.7 billion in loan support for 1,025 MW of capacity and biofuel projects received over \$237 million (project sizes are unknown) (Feldman 2011).

Possible reasons for the lack of broader participation by lenders include (1) few lenders with both geothermal and DOE loan guarantee program expertise, which likely results in (2) high transaction costs, and (3) a perception of lending to higher-risk projects because of the need for a loan guarantee (NREL analysis; Ormat 2010a).

An additional potential barrier to loan guarantees is the mismatch between the long timeframe for geothermal project development and the limited window for participation in the 1705 program. It typically takes 4 to 8 years to bring a geothermal project on line. The 1705 program was not enacted until 2009 (Salmon et al. 2011). Thus, 2013 is likely the earliest point that new, incremental projects would be ready to apply for a loan guarantee. It is more likely that projects already under development came into maturity at the right time to apply for the 1705 program. For example, the three geothermal projects approved for loan guarantees in late 2009 to mid-2011 were well underway before the 1705 program was enacted (i.e., before fall 2009).³⁶

³⁶ The Nevada Geothermal Power Company's Blue Mountain project was in the resource development stage as of 1999 and the initial well development stage in 2006 (Melosh et al. 2008; Nevada Geothermal Power 2006). U.S. Geothermal Power Inc. received a drilling permit in 2008 for the Neal Hot Springs site (RedOrbit 2008). As of March 2009, Ormat's McGinness project was in Stage 2 of development with exploration and/or drilling permits approved, exploration drilling conducted/in progress, and transmission feasibility studies underway. The Jersey Valley and Tuscarora projects were in Stage 3 of development (i.e., securing PPA and final permits, full size wells drilled, financing secured for portion of project construction, interconnection feasibility study complete) in 2009 (Slack 2009). See footnote 8 for a description of the various stages of development as defined by GEA.

Historic Federal Geothermal Programs

The oil and gas industry drills thousands of wells onshore in the United States each year; however, fewer than 100 geothermal wells are drilled (DOE 2008b). Although much of the equipment and drilling techniques used for geothermal wells are similar to those used for oil and gas, geothermal is a smaller and, perceived to be, riskier market.

Despite the additional costs in early geothermal exploration, developers can expect a success rate for exploratory wells of 35% to 50% (Young et al. 2010; Kanellos 2011).³⁷ Interestingly, onshore oil-exploration success rates are reported to be around 46%. Offshore success rates are reported to be slightly higher at 51% (EIA 2008; ECG 2005; NGOG).

Most of the risk of a geothermal project occurs in the initial stages of development, namely in resource identification, resource evaluation, and test drilling. Together, these three steps account for an estimated 13% of the overall cost of a project or approximately \$390 to \$520/kW-installed.³⁸ [Production-well drilling and plant construction account for the remaining 38% and 49% of the costs, respectively (Cross and Freeman 2009)]. Because of the risks associated with these steps (i.e., the possibility of dry wells), the cost of financing early stages of development is high, thereby augmenting the cost of the initial development stages (Salmon et al. 2011). Additional risk is associated with early-stage geothermal development in greenfield areas where resources have not been proven and where the majority of projects are in development (GEA 2011a).³⁹

To help address these high costs and risks, a recent report for DOE recommended a cost-sharing program for exploratory drilling (Deloitte 2008). This program would be based in part on DOE's Industry-Coupled Drilling program, which was active from 1978 through 1982. Both the U.S. Congress and the DOE (and precursor organizations) enacted a variety of additional cost-share programs during the late 1970s to mid-1980s that provided significant financial support to projects, including the original Loan Guaranty Program and the Program Opportunity Notices (PONs) (DOE 2008b).⁴⁰ The Loan Guaranty Program supported exploration and field development via a 25% equity cost-share by the developer with the government guarantee covering the remaining 75% of the project debt (U.S. GAO 1980). PON established "demonstration projects in which project costs are shared between DOE and the private companies, municipalities, or organizations that are conducting the demonstrations" (Parker 1982).

³⁷ The success rate of 50% for the Blue Mountain project was described in Kanellos 2011 as "unusually high."

³⁸ This estimate is based on approximate project costs of \$3,000 to \$4,000/kW, and actual project costs are highly dependent on project size and location, among other factors (Cross and Freeman 2009). For additional information on estimated costs for each stage of geothermal project development, see Salmon et al. 2011.

³⁹ Greenfield sites are where previous development is either minimal or non-existent. Of the total 146 conventional geothermal projects in development in 2011, 111 (or 76%) are being developed on a greenfield site (GEA 2011a).

⁴⁰ For details on the history of the pre-DOE federal U.S. geothermal programs and DOE geothermal programs, see DOE 2008b. The 1970s program is spelled as "guaranty," whereas the program enacted under the 2005 *Energy Policy Act* is spelled "guarantee." See the DOE Geothermal Technologies Program website (<http://www1.eere.energy.gov/geothermal/history.html>) for more historical DOE GTP program information.

These cost-share programs resulted in the exploration, identification, and development of many of the resource sites in use today (DOE 2008b).⁴¹ Table 5 lists DOE-supported sites noted in the 2008 report, *Geothermal Technologies Program: Multi-Year Research, Development, and Demonstration Plan*, as well as additional sites believed to have been developed after the initial supported resource development. The installed capacity is from currently operating geothermal plants that are believed to have resulted from drilling, exploration, and resource development done under the initial cost-share programs. Projects supported under other federal efforts were excluded. Such projects include those at Geysers and Steamboat Springs, which amounted to 1,730 MW of operating installed capacity. See the Appendix for a detailed list of the estimated subsequent commercial plants.

Table 5. Currently Operational Geothermal Plants Resulting from DOE-Sponsored Sites from Late-1970s to Early-1980s Programs⁴²

DOE Developed Site	Capacity	DOE Developed Site	Capacity
Boewawe: Beowawe, NV	18 MW	Hawaii Geothermal Area: Pahoia, HI	35 MW
Coso Junction: China Lake, CA	302 MW	Raft River: Cassia County, ID	16 MW
Desert Peak: Churchill County, NV	9 MW	Roosevelt Hot Springs: Milford/Beaver, UT	42 MW
Dixie Valley: Dixie Valley, NV	64 MW	Salton Sea: Calipatria, CA	339 MW
Imperial Valley: Imperial County, CA	102 MW	Soda Lake: Fallon, NV	23 MW
Honey Lake: Lassen County, CA and Washoe County, NV	55 MW	Stillwater: Fallon, NV	48 MW
Mammoth-Pacific: Mono County, CA	40 MW		
TOTAL: 1,093 MW (Current U.S. installed capacity is 3,102 MW)			

Sources: Adapted primarily from DOE 2008b. Additional sources: CalEnergy Generation 2011; Calpine; DOE 1984; DOE 1995; DOE 2008a; DOE 2011; Lewis and Ralph 2002; McLarty and Reed 1992; Morse 1979; Ormat 2011; PacifiCorp 2011; Puna 2009; Terra-Gen 2008; U.S. Geothermal Inc. 2007a; U.S. Geothermal Inc. 2007b; U.S. Geothermal 2007c; and U.S. Geothermal 2009

⁴¹ The cost-benefit ratio of this portfolio of programs is unknown. However, a 2010 DOE report analyzed the cost-benefits of DOE support for four technology clusters, including projects conducted during the mid-70s to mid-80s as well as others completed more recently. *Retrospective Benefit–Cost Evaluation of U.S. DOE Geothermal Technologies R&D Program Investments: Impacts of a Cluster of Energy Technologies* found that the support for the four technology clusters provided “as a group, ...significant economic, environmental, and knowledge benefits.” See Gallaher et al. 2010 for details.

⁴² Although listed in the DOE’s *Geothermal Technologies Program: Multi-Year Research, Development, and Demonstration Plan* report as being DOE-sponsored sites, examples of participation in late 1970s to early 1980s cost-share, loan guaranty program, etc., were not found for the Geysers or Steamboat. Therefore, they were removed from this list. However, the DOE supported the Geysers and Steamboat sites during later periods (Bodvarsson 1992). Current capacity at the Geysers is 1,589 MW, and there is 141 MW of installed capacity at Steamboat Springs. Cove Fort Sulphurdale in Utah was supported under the DOE Industry-Couple program and produced electricity between 1985 and 2003; the plant may be brought back online in the future (DOE Exploration). The Capacity column is “installed” or “nameplate” capacity. Running capacity may be higher or lower than installed capacity; however, only installed/nameplate capacity was used for consistency.

There are several possible reasons for the effectiveness of the DOE's cost-share, loan guarantee, and grant programs of the late 1970s and early 1980s. First, the industry-coupled cost-share was relatively significant, amounting to between 20% and 90%, depending on the project's success (Bloomquist et al. 2007). And similarly, DOE grant programs, like PONs, provided significant support for exploration and confirmation drilling in the form of grants. Second, few resources had been developed, so industry and the DOE were able to "cherry pick" from the best resources.⁴³ However, while these earlier investments by the DOE were effective in developing the geothermal market, they may not have leveraged as much private capital as other programs, like the 1705 DOE loan guarantee program has done thus far.

⁴³ Substantial geothermal capacity did not begin to come online until the 1970s, despite the fact that geothermal project development began in the late 1800s (DOE 2011). Thus, few resources had been previously developed.

Conclusion

The United States has more operating installed geothermal capacity than any other country, contributing nearly one-third of global capacity. Much of the market build-out is due to investments by the U.S. government and DOE in the late 1970s and 1980s, and more recently, to federal tax incentives (coupled with additional state and local programs, which are outside of the scope of this report).

As shown in the CREST analysis, federal tax incentives provide significant value to geothermal projects in terms of reducing the LCOE. The exact value depends on the specific choice of incentives.

1. When project debt was optimized for a given set of incentives, the overall value of the incentives was augmented by choices that allow projects to take on additional debt. For example, the LCOE for the PTC + MACRS at 50% debt is \$0.0782, which is slightly higher than the debt-optimized LCOE of \$0.0761. Thus, the value of incentives may have an intrinsically lower or higher value when considering both the direct effect of the incentives on the LCOE and indirect effects, which may impact a project's financials or other outcomes.
2. In the scenario with 50% debt and a 15-year loan tenor, the two test cases of the PTC + 100% Bonus (now expired) and PTC + 50% Bonus did not meet the minimum annual DSCR of 1.2 or the average DSCR of 1.45.⁴⁴ This is because CREST, based on the debt assumptions, applies the PTC toward meeting the IRR rather than repaying debt principal and interest. Thus, there is the potential that a project developer, using either the PTC + 100% or the PTC + 50% Bonus combinations, could face challenges to taking on as much debt as is possible under other incentive combinations. Potential solutions to passing the DSCR using current assumptions include only taking MACRS with the PTC (and forgoing the bonus depreciations) and reducing the amount of debt, among other possibilities.
3. At a constant debt ratio of 50%, the PTC + MACRS, the 30% Grant + 100% Bonus, and the 30% ITC + 100% Bonus provided the greatest value while also passing the minimum DSCR.
4. The choice between the ITC and Treasury cash grant makes no difference on the LCOE, but developers usually value the cash grant more than tax credits because it (1) is received in cash, (2) is received more quickly, and (3) reduces the need for a tax equity investor (although a tax equity investor may be needed to provide a type of bridge financing post-construction and before the system is placed in service) (Marciano and Katz 2010).

Even with the tax incentives and DOE loan guarantees, geothermal market growth is near stagnant. And with the larger tax incentives (100% Bonus, the PTC and the 30% ITC) having expired or nearing expiration and the sunset of the 1705 DOE loan program, geothermal market growth may be further stymied.

Three geothermal loan guarantees were issued: Nevada Geothermal Power Co.'s Blue Mountain project; U.S. Geothermal's Neal Hot Spring; and Ormat Nevada's McGinness, Jersey Valley,

⁴⁴ These assumptions are based on recent conversations with a few industry representatives. It is possible to reduce the fraction of debt and it may be possible to reduce the required DSCR (with insurance products or other risk mitigation measures).

Tuscarora projects. There are several possible reasons why few geothermal projects have received loan guarantees, including (1) a lack of interest by developers, (2) long project timelines, which makes the timing of the application difficult, and (3) disinterest by investors. Geothermal projects may have also been rejected for a loan guarantee. Another possibility is that due to the long timeline of these projects, there may have been additional projects that could not meet the 1705 program deadline.

Policymakers seeking to spur geothermal development may wish to consider additional policies to support the industry. A 2008 report to the DOE GTP suggested a cost-share program to support drilling and exploration. The report recommended a program based on earlier U.S. federal programs (e.g., the DOE Industry-Coupled Drilling Program and Loan Guaranty [sic] Program), which are estimated to have resulted in roughly 1,093 MW of currently operating capacity. Success of these earlier programs was likely due to the significant level of support provided by the government towards initial resource studies and project development, as well as the availability of high-quality resources. Policymakers may want to consider experiences from these earlier programs to determine whether they would be effective at spurring drilling and exploration in today's geothermal electric market.

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Appendix: Estimated Plants Resulting from Late 1970s—Early 1980s DOE Programs

Table A-1 lists DOE-supported geothermal sites and the subsequent commercial utility-scale geothermal plants that are believed to have resulted from the initial exploration and drilling efforts. As there is not a comprehensive list of DOE geothermal support efforts and the resulting plants, this list is estimated based on the consultation of various resources. Some of the plants listed may not have resulted directly from a DOE-supported effort, although development of a DOE-supported plant may have indirectly led to the development of additional plants at the same site (i.e., resulting from the developer having proven the resources). Plants built before the DOE-supported efforts were removed. The following table should be considered as a guide or initial research and not as a definitive list.

Table A-1. Complete List of Commercial Plants Estimated to Have Resulted from DOE Programs in the 1970s and 1980s

DOE Developed Site Under 1970s to 1980s		Estimated Resulting Commercial Plants	
Name & Location	Program & Year	Installed Capacity and Beginning Year of Construction	Total Capacity
Beowawe Beowawe, NV	Industry-Coupled Program: between 1978 and 1981	Beowawe (18 MW), 1985	18 MW
Coso Junction Coso Hot Springs - China Lake, CA	DOE-funded test well drilling, 1977; additional exploration support throughout the late 1970s and early 1980s.	Navy I (102 MW), 1987; Navy II (100 MW), 1989; BLM (100 MW), 1988	302 MW
Desert Peak Churchill County, NV	Industry-Coupled Program: between 1978 and 1981	Desert Peak (9 MW), 2006	9 MW
Dixie Valley Dixie Valley, NV	Industry Coupled Program: between 1978 and 1981	Dixie Valley (64 MW), 1988	64 MW
Honey Lake Lassen County, CA and Washoe County, NV	Industry-Coupled: 1982, 1984	Steamboat I (8 MW), 1986; Honey Lake (2 MW), 1989; Wineagle (1 MW), 1985; San Emidio (44 MW), 2011	55 MW

DOE Developed Site Under 1970s to 1980s		Estimated Resulting Commercial Plants	
Imperial Valley Imperial County, CA	Loan Guaranty: 1978	Ormesa IE (10 MW), 1988; Ormesa IH (12 MW), 1989; (18 MW), 1989); 2008; Ormesa I (44 MW) 1986; Ormesa II (18 MW), 1987	102 MW
Mammoth-Pacific Mono County, CA	DOE-funded feasibility study 1979	Mammoth Pacific 1 (10 MW), 1984; Mammoth Pacific 2 (30 MW), 1990	40 MW
Hawaii Geothermal Area Pahoa	DOE-funded demonstration plant 1976	Puna Geothermal Venture I (35 MW), 1993	35 MW
Raft River Cassia County, ID	Demonstration Project - 1974	Raft River (16 MW), 2008	16 MW
Roosevelt Hot Springs Milford/Beaver, UT	Industry-Coupled: 1977 - 1979	Blundell I Roosevelt Hot Springs (23 MW), 1984; Blundell II/Roosevelt Hot Springs (9 MW), 2007; Thermo Hot Springs (10 MW), 2009	42 MW
Salton Sea Calipatria, CA	DOE Cost-share of the Geothermal Loop Experimental Facility: 1976	CE Turbo (20 MW), 2000; Elmore (38 MW), 1989; Leathers (38 MW), 1990; Vulcan: 1986 (35 MW); Del Ranch (38 MW), (1989); Salton Sea 1, (10 MW) 1982; Salton Sea 2 (21 MW), 1990; Salton Sea 3 (50 MW), 1989; Salton Sea 4 (40 MW), (1996); Salton Sea 5 (49), 2000	339 MW
Soda Lake Fallon, NV	Industry-Coupled Program: between 1978 and 1981	Soda Lake (5 MW), 1987; Soda Lake II (18 MW), 1991	23 MW
Stillwater Fallon, NV	Industry-Coupled Program: between 1978 and 1981	Stillwater (48 MW), 2009	48 MW
TOTAL: 1,093 MW			