GRC Transactions, Vol. 41, 2017

Crossing the Barriers: An Analysis of Permitting Barriers to Geothermal Development and Potential Improvement Scenarios

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Keywords

Permitting, environmental, geothermal, GeoRePORT, development timelines, NEPA

ABSTRACT

Developers have identified many non-technical barriers to geothermal power development, including permitting. Activities required for permitting, such as the associated environmental reviews, can take a considerable amount of time and delay project development. This paper discusses the impacts to geothermal development timelines due to the permitting challenges, including the regulatory framework, environmental review process, and ancillary permits. We identified barriers that have the potential to prevent geothermal development or delay timelines and defined improvement scenarios that could assist in expediting geothermal development and permitting timelines and lead to the deployment of additional geothermal resources by 2030 and 2050: (1) the creation of a centralized federal geothermal permitting office and utilization of state permit coordination offices as well as (2) an expansion of existing categorical exclusions applicable to geothermal development on Bureau of Land Management public lands to include the oil and gas categorical exclusions passed as part of the Energy Policy Act of 2005. We utilized the Regional Energy Deployment System (ReEDS) and the Geothermal Electricity Technology Evaluation Model (GETEM) to forecast baseline geothermal deployment based on previous analysis of geothermal project development and permitting timelines. The model results forecast that reductions in geothermal project timelines can have a significant impact on geothermal deployment. For example, using the ReEDS model, we estimated that reducing timelines by two years, perhaps due to the creation of a centralized federal geothermal permitting office and utilization of state permit coordination offices, could result in deployment of an additional 204 MW by 2030 and 768 MW by 2050 – a 13% improvement when compared to the business as usual scenario. The model results forecast that a timeline improvement of four years – for example with an expansion of existing categorical exclusions coupled with the creation of a centralized federal geothermal permitting office and utilization of state permit coordination offices – could result in deployment of an additional 2,529 MW of geothermal capacity by 2030 and 6,917 MW of geothermal capacity by 2050 – an improvement of 116% when compared to

the business as usual scenario. These results suggest that reducing development timelines could be a large driver in the deployment of geothermal resources.

1. Introduction

Permitting and the associated environmental assessments can take a considerable amount of time and delay or prevent project development; understanding these challenges and arriving at potential solutions could increase geothermal deployment. Recent studies (Young et al., 2014) showed that the presence of certain resources and/or previous uses could cause projects to be delayed several years or more. In 2015, the Geothermal Technologies Office (GTO) at the U.S. Department of Energy (DOE) initiated a vision study (GeoVision) to conduct analysis of potential growth scenarios across multiple geothermal market sectors (e.g. electricity generation, commercial and residential thermal applications, heat pumps) for 2030 and 2050. As part of the GeoVision, the National Renewable Energy Laboratory (NREL) led an Institutional Barriers Task Force charged with analyzing non-technical barriers that create delay, increase risk, or increase the cost of project development. The non-technical barriers analyzed by the task force include land access, permitting, transmission, and market conditions. This paper focuses only on the impacts on geothermal development timelines due to permitting and associated environmental reviews (e.g. the National Environmental Policy Act or state equivalents) and how current timelines impact geothermal deployment. Other papers describe the results for the other non-technical barriers analyzed.

In this paper we discuss:

- The methodology used to analyze permitting barriers, including analyzing permitting as an “attribute” to geothermal development
- The sub-attributes that make up the permitting attribute and a description of the barriers caused by each sub-attribute for geothermal development
- The influence that permitting barriers have on development timelines and potential deployment of geothermal resources
- Potential improvement scenarios to overcome permitting barriers that may delay geothermal development and reduce geothermal deployment.

2. Methodology

2.1 The GeoRePORT System

The GeoRePORT System was developed to address the need of the GTO to track and measure the impact of research, development, and deployment funding for GTO-funded geothermal projects (Young et al., 2015). While other geothermal reporting systems exist, such as the Australian and Canadian Geothermal Reporting Codes (AGEA and AGEG 2010, CanGEA 2010) and the United Nations Framework Classification (UNFC) System (UNECE, 2013), the GeoRePORT System is unique in providing a detailed system for reporting both the resource grade and the project progress (a.k.a. project readiness level), and is particularly useful for describing early-stage exploration projects. The analysis presented in this paper discusses only resource grade, and not project readiness levels. GeoRePORT is comprised of three assessment tools: Geological, Technical, and Socio-Economic. Each of the assessment tool’s resource grades is divided into attributes and sub-attributes that describe the characteristics that contribute to feasibility of project development (Figure 1).

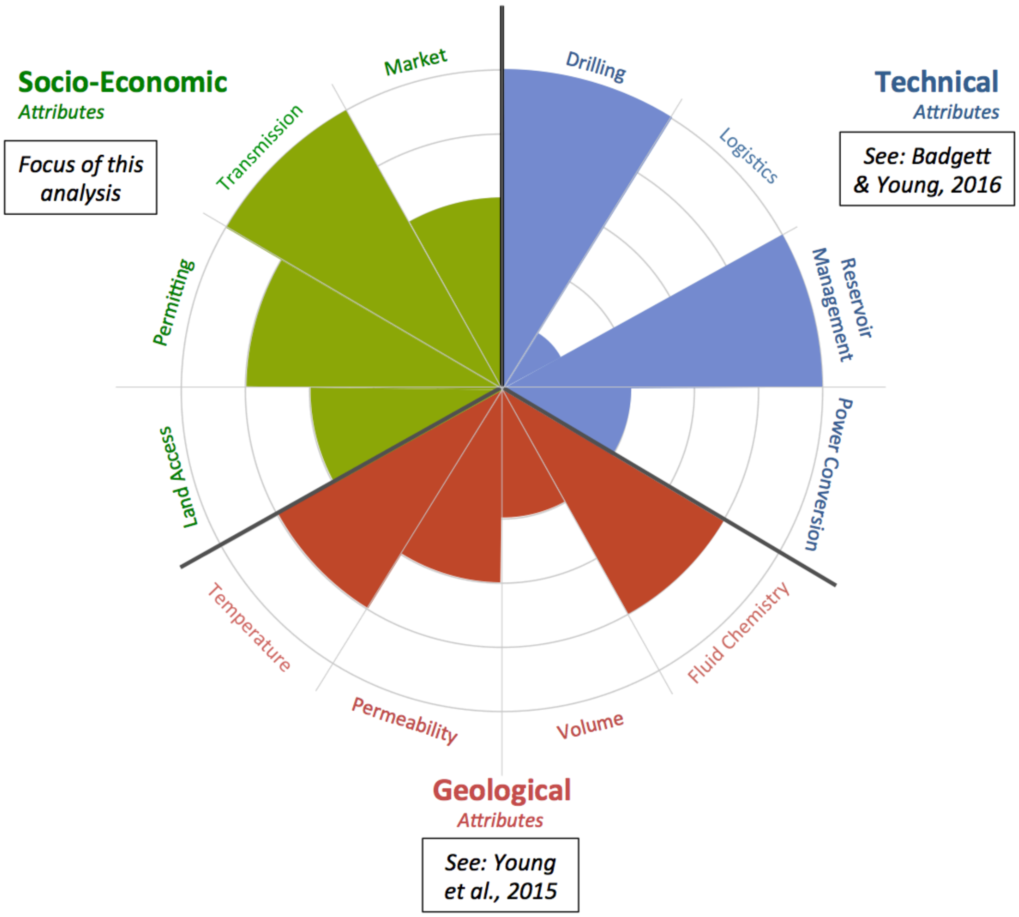


Figure 1. ***Resource Grades.*** The grade of a resource can be described as a combination of intrinsic features of the resource that contribute to economic viability. The GeoRePORT System allows developers to assign grades to each of twelve attributes, providing a clear picture of the development potential and challenges at each location. The highest grade, A, is represented as a full pie piece; the lowest grade, E, is represented as the smallest pie piece. Geological attributes include temperature, volume, permeability, and fluid chemistry. Technical attributes include drilling, logistics, reservoir management, and power conversion; socio-economic attributes include land access, permitting, transmission, and market. Sub-attribute grades, activity and execution indices are not reported in this graphic.

Previous work focused on the development of the Geological Assessment Tool (GAT, Young et al., 2015), the Technical Assessment Tool (TAT, Badgett and Young, 2016), and the Socio-Economic Assessment Tool (SEAT, Levine and Young, 2016). This paper focuses on use of the Socio-economic grade to analyze land access barriers. Related research and final draft protocol documents for all three tools can be found on the GeoRePORT website (http://en.openei.org/wiki/GeoRePORT).

In addition to the character grade (A–E) for each attribute, the GeoRePORT resource grading system includes an activity index and an execution index. The activity index describes the common activities used to understand the character attributes – both directly (measured values) and indirectly (proxy). The activity index is graded from A–E as well, with E representing the lowest level of certainty. For example, an activity grade of A (high certainty) for land access may be that an environmental assessment has been completed for the project.

For the purposes of the baseline analysis conducted for this GeoVision Study, the activity grade is E, reflecting that the data used are national-level spatial datasets and datasets we created based on our general knowledge of a state or region. Developers who begin exploration and research in a specific area will certainly research each attribute and sub-attribute in greater detail. This research may change (increase or decrease) the reported resource grade, and would increase the activity index, indicating a greater certainty in the reported land access character grade.

For the GAT and TAT, the grades also make use of an execution index, describing how well an activity (e.g., geothermometry) was implemented. The execution index is not used in the reporting of Socio-Economic resource grades.

2.2 Use of the GeoRePORT to Analyze Institutional Barriers

The SEAT of GeoRePORT includes four attributes: Land Access, Permitting, Transmission, and Market, each of which includes sub-attributes. The sub-attributes are assigned grades which, when combined, provide a single character grade for each attribute. As mentioned, the permitting attribute has three sub-attributes: regulatory framework, environmental review process, and ancillary permits. Each sub-attribute is graded from A-E. Table 1 shows how the environmental review process sub-attribute may be reported.

Table 1. Example list of Sub-Attribute Grades for the Environmental Review Process Sub-Attribute of the Permitting Attribute.

Environmental Review Process Sub-Attribute Character Grade	Description	Estimated Time Frame
A	If the project is not subject to any federal or state environmental review process for any permits required for the project or environmental review is complete.	County approval assumed to take less than 180 days.
B	If the project is subject to **one** federal or state environmental review process for any permits required for the project.	Federal review <12 months, State review <12 months.
C	If the project subject to **two** federal or state environmental review process for any permits required for the project.	Federal and State review will take 18-24 months.
D	If the project is subject to **one** federal or state environmental review process for any permits required for the project and **has a significant impact on the environment**.	Review will take > 24 months
E	If the project is subject to **two** federal or state environmental review process for any permits required for the project and **has a significant impact on the environment**.	Review will take > 24 months and results in no-go decision.

Each sub-attribute (SA) is given a weight (wt), and the total sub-attribute-weighted sum would be calculated as:

$$\text{Sub-attribute-weighted sum} = SA_1{*}wt_1 + SA_2{*}wt_2 + SA_3{*}wt_3 + \ldots + SA_n{*}wt_n \quad (eq\ 1)$$

where Grade A=5 and E=1. The range of attribute-weighted sums is then broken down into grades A-E for each attribute. For example, for permitting, the maximum weighted sum (if all grades are A) is 30, while the minimum weighted sum (if all grades are E) is 6. The breakdown of grades based on weighed sum is as follows:

Table 2. Table of sub-attribute-weighted sum ranges for the Permitting attribute. The grades for all sub-attributes are multiplied by the corresponding sub-attribute weight, then added together to calculate the sub-attribute-weighted sum. This sum is then used to determine the attribute character grade using this table.

Permitting Character Grade	Sub-attribute Weighted Sum
A	28-30
B	22-27
C	16-21
D	10-15
E	6-9 or any single *significant barrier* sub-attribute grade

Table 3. Permitting Activity Index. For each Permitting sub-attribute, an activity grade is assigned using the following index. It is often the case that all sub-attributes will have the same activity grade.

	Permitting Activity Index	Description
Higher certainty	A	Power plant and ancillary facilities permits approved
	B	Well field permits approved
	C	Exploration permits approved
	D	Review of National Environmental Policy Act of 1969 (NEPA) analyses for nearby projects indicate potential concerns in the area
Lower certainty	E	Permitting process has not yet begun

2.3 Institutional Barriers Expert Team

For the institutional barriers analysis we assembled a barriers expert team (BET) of geothermal experts from industry and federal agencies to provide regular, scheduled input and review of our methodology and results through monthly meetings and document review (see *Acknowledgments*).

We began by creating the socio-economic attributes and sub-attributes to reflect the non-technical barriers faced by the geothermal industry, as shown in Figure 2. We then created a grading system, providing each sub-attribute with a descriptive, objective qualifier for letters A-E, with E reflecting the most difficult barrier for the sub-attribute (e.g., Table 1). After grading each sub-attribute, we created a grade from A-E for each attribute that reflects the weighted sums of the sub-attributes to reflect the most difficult barrier for the attribute (e.g., Table 2).

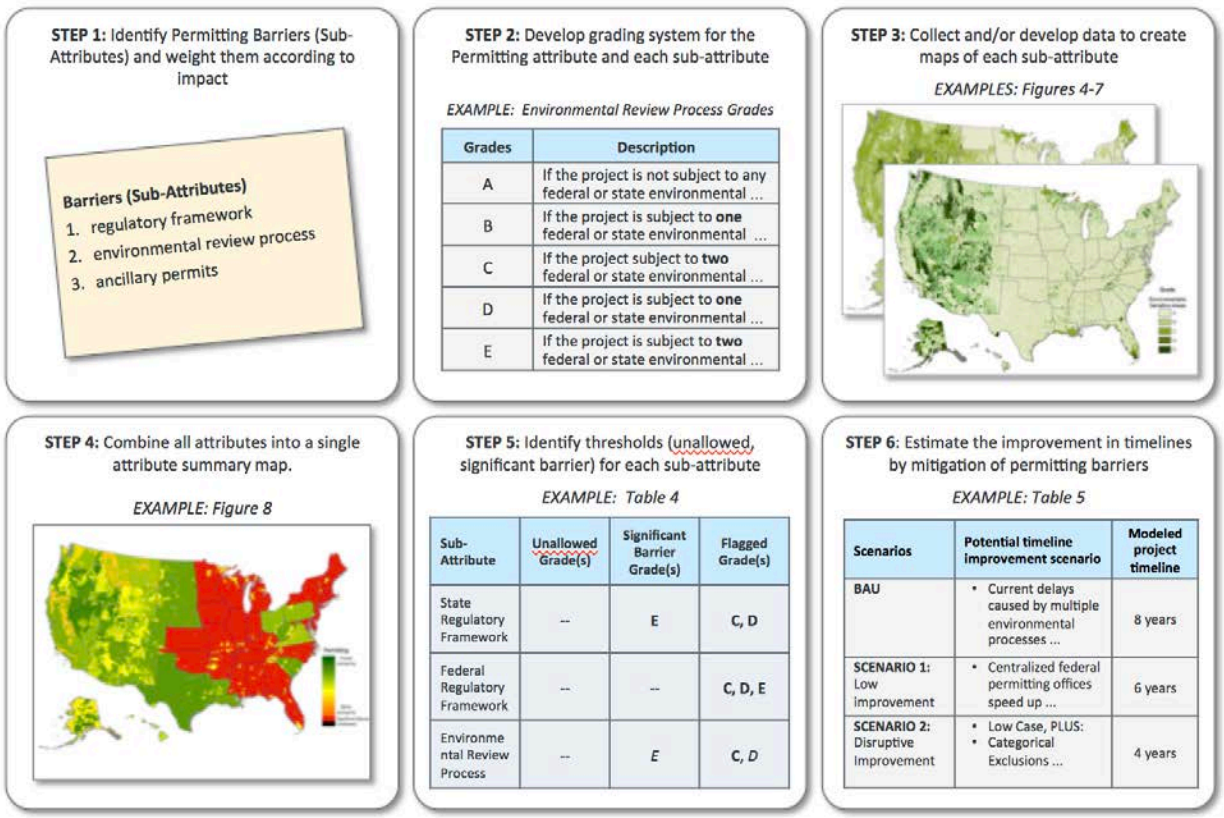


Figure 2: Barriers Analysis Process. Diagram shows the steps in the process of identifying barriers, developing a grading system, mapping the data, and analyzing the impact on geothermal development potential.

Next, we collected and/or created data to map each sub-attribute for the United States. We then identified specific thresholds for sub-attributes, if applicable, which would currently make a project *unallowed* and blacked them out on the map. For example, for the Biological Resources sub-attribute described in Table 1, any area mapped as a grade E was determined to be currently *unallowed* for project development and was blacked out on the Biological Resources grade map (Figure 6). We also interviewed developers and members of the BET to understand their criteria for decision-making on geothermal projects, recording specific situations they would currently consider a *significant barrier* or might raise *flags* for project development. For example, all of the developers we interviewed said they would consider Sage Grouse PHMAs (grade D) to be a *significant barrier* situation.

The BET also assigned weights to each of the sub-attributes based on the sub-attributes' contribution to development barriers. Sub-attributes that had the potential to cause significant barriers (e.g., biological resources) were given higher weights than those that caused less significant barriers (e.g., land ownership).

The results of these analyses are presented in Section 3.

After completing this process, we combined the sub-attribute maps into a single land access attribute map (Figure 11) using the BET-defined sub-attribute weights. The land access attribute map reflects the attribute grade (i.e., weighed sum of the sub-attribute grades), including all of the areas where development was *unallowed*. All maps are available on Geothermal Prospector (https://maps.nrel.gov/geothermal-prospector) and the Geothermal Data Repository (https://gdr.openei.org).

We overlaid the attribute and sub-attribute maps over USGS maps of identified and undiscovered resource potential in the United States to assess the amount of resource potentially impacted by land access barriers. The Land Access summary map and impact to geothermal potential is presented in Section 4.

2.4 Market Penetration Modeling Methodology

The next step was to develop geothermal supply curves using the resource assessment methodology described above in conjunction with the Geothermal Electricity Technology Evaluation Model (GETEM). GETEM is an Excel-based tool used to estimate the levelized cost of energy (LCOE) for definable geothermal scenarios, as shown in Figure 3.

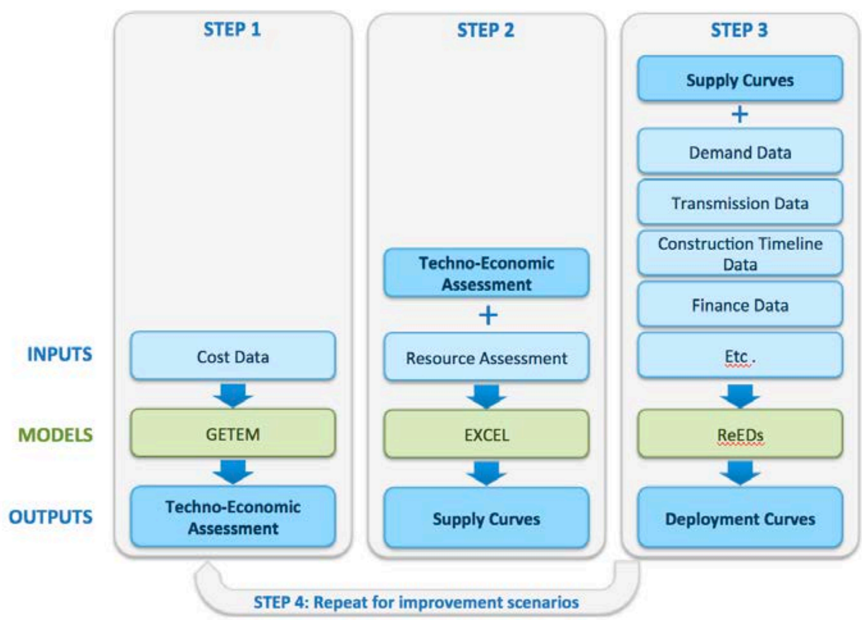


Figure 3. Market Penetration Modeling Process. Diagram shows the steps in the process of running various scenarios, including Business-As-Usual scenarios (including non-technical barriers) and Improvement Scenarios (including potential for reducing these non-technical barriers). The ReEDs model competes geothermal deployment with other renewable and non-renewable resources.

These supply curves were used as input (using several scenarios) into NREL's Regional Energy Deployment System (ReEDs) to understand how these barriers impact potential deployment of geothermal in the United States. The ReEDS model is a long-term capacity model for the deployment of electric power generation technologies and transmission infrastructure throughout the contiguous United States.[1]

The GeoVision utilized a combination of ReEDS and GETEM to forecast both baseline deployment scenarios and potential improvement scenarios for geothermal deployment in the contiguous United States.

The results of the market penetration modeling for Business-As-Usual (BAU) and Land Access Improvement scenarios are presented in Section 5.

3. Analysis of Geothermal Permitting Barriers

This section discusses the definition of each permitting sub-attribute grade and the results of mapping the grades for each permitting sub-attribute and the permitting attribute. Development of a geothermal project requires a variety of different permits, and these vary from state to state. The administrative procedures to obtain these permits involve several federal, regional, and local authorities. Delays can be caused by many factors, including a lack of knowledge of the details of geothermal development, under-staffed offices, vacation schedules, or the number of permits and/or parties involved. These complex and sometimes time-consuming procedures can impact the investment potential of the geothermal project (Levine et al., 2013).

These issues are not unique to the United States, and there are instances where authorities have begun to address these barriers. For example, Europe's Renewable Energy Sources, or RES, Directive[2] requires member states to streamline and rationalize the administrative procedures required for awarding permits to renewable energy projects. It requires member states to define and coordinate the respective responsibilities of national, regional, and local administrative bodies for authorization, certification, and licensing procedures, including spatial planning (Dumas et al., 2015). Similarly, Alaska has established a Large Project Coordination process that when possible attempts to integrate the NEPA process with the state permitting process (Levine et al., 2013). The California Energy Commission coordinates permits and state environmental review for geothermal projects greater than 50 MW.

The permitting attribute is divided into three sub-attributes that reflect the structures and situations that create challenges as well as those that facilitate streamlining of the geothermal permit process. The permitting sub-attributes include:

1. Regulatory Framework
    a. State Regulatory Framework
    b. Federal Regulatory Framework
2. Environmental Review Process
3. Ancillary Permits

[1] For more information see: http://www.nrel.gov/analysis/reeds/
[2] The Directive on Electricity Production from Renewable Energy Sources is a European Union directive for promoting renewable energy use in electricity generation. It is officially named 2001/77/EC and popularly known as the RES Directive.

3.1a Barrier 1a: State Regulatory Framework

The state regulatory framework sub-attribute grades and map (Figure 4) address the relative sophistication of the permitting regulations and knowledge within the state specific to geothermal development. Our grading of each state was based on our review of state regulations and a review of active geothermal power plants permitted in the state. The grade relates primarily to development on state and private lands within the state. For example, while Alaska, California, Oregon, Nevada, Idaho, and Utah have experience developing geothermal power in their respective states, Alaska additionally has an effective permit coordinating process that facilitates permitting in the state (Levine et al., 2013).

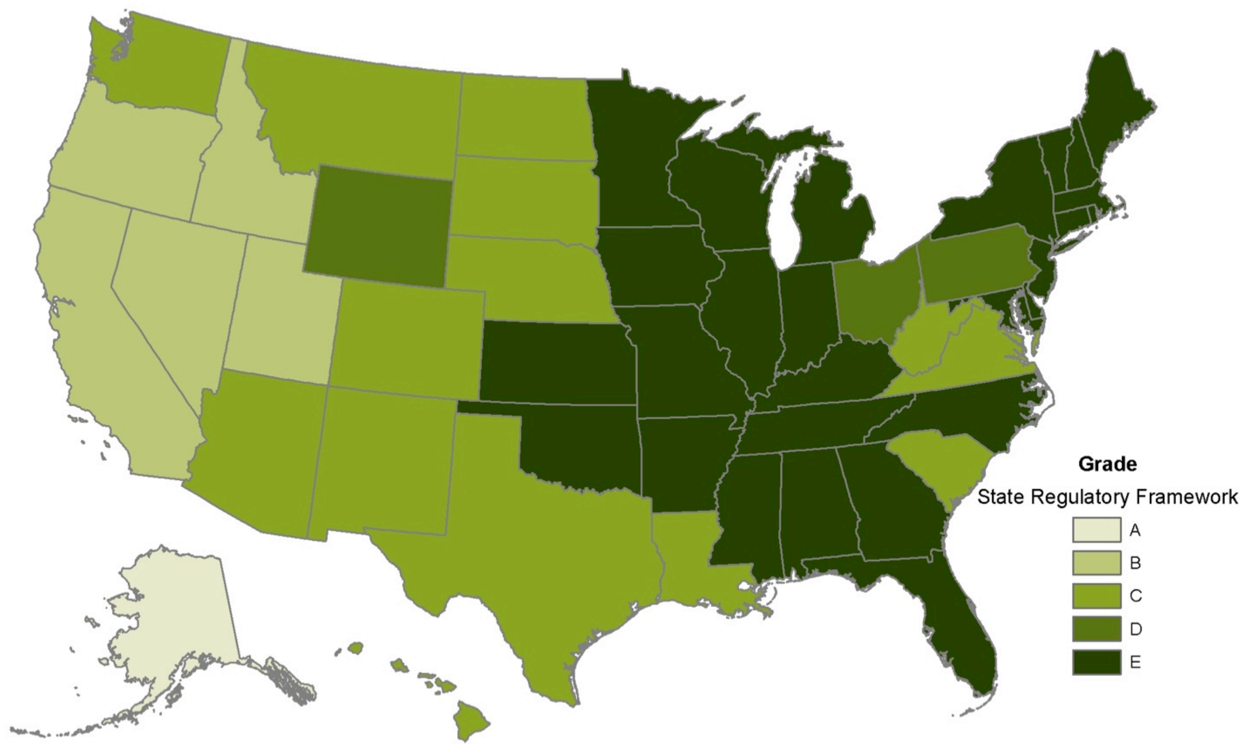
3.1a.1 State Regulatory Framework Grading and Map

For this sub-attribute, experts stated that while a lack of geothermal regulations wouldn't prevent development, it would likely be *a significant barrier* potentially preventing them from pursuing development. Additionally, grades C and D would raise *flags* with developers. For example, in the state of Colorado (grade C), developers have stated that they have encountered resistance from financers; they say financers find it too risky to invest in a state where the geothermal (and water rights) regulations have not yet been tested. There are no *unallowed* grades for this sub-attribute.

3.1b Barrier 1b: Federal Regulatory Framework

The federal regulatory framework sub-attribute grades and map (Figure 5) address the geothermal experience of the permitting experts and knowledge within regional offices (U.S. Bureau of Land Management (BLM) district level or U.S. Forest Service (USFS) land) specific to geothermal development as well as whether the regional office has a Memorandum of Understanding (MOU) with the applicable state. Our grading focused on a review of whether regional offices had MOUs with the applicable state, had previously permitted geothermal power plants, and had geothermal specific staff or funding.

A lack of experienced regulatory personnel and lack of inter-agency coordination were two situations cited by industry and agency personnel to delay geothermal project development (Young et al., 2014). The map shown in Figure 5 geographically identifies BLM field office areas with experience and facilitated coordination (MOUs) with the state regulatory agencies. These grades apply only to development on federal lands in these regions. This sub-attribute applies only to federal lands and complements the map in 3.1a State Regulatory Framework.

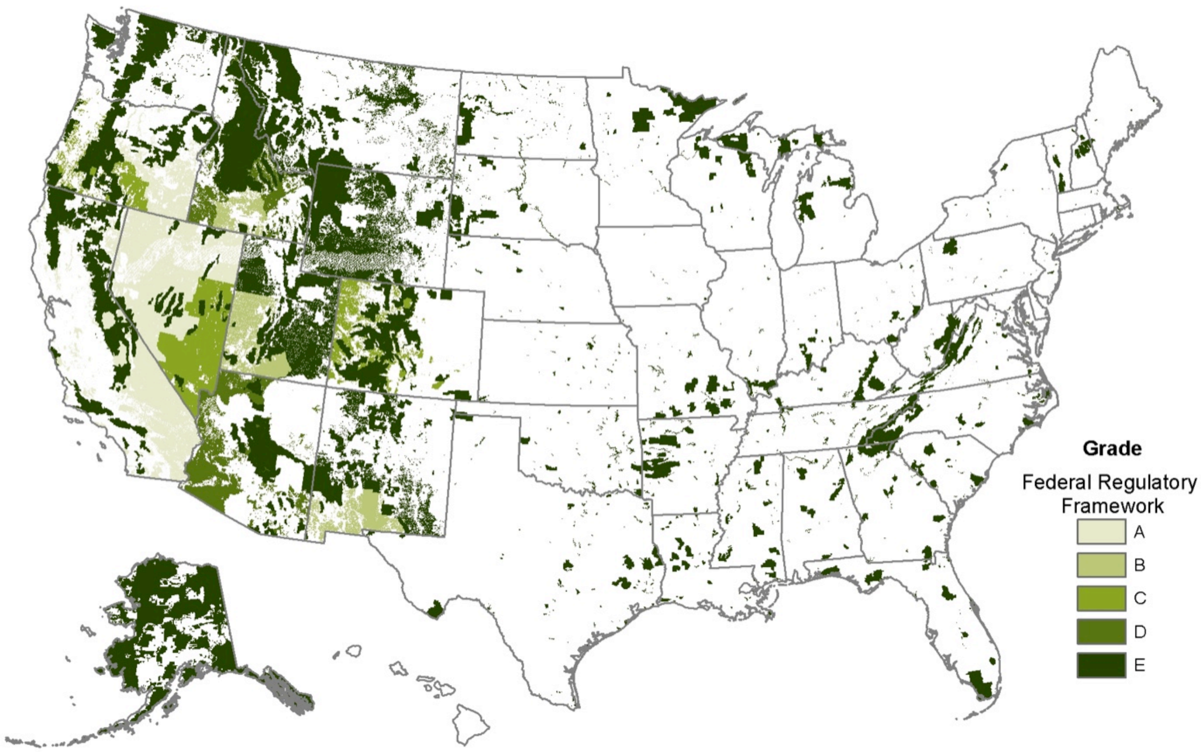


A	State/County has a permit coordinating office, geothermal regulations and experience successfully permitting projects	
B	State/County has geothermal regulations and experience successfully permitting projects	
C	State/County has geothermal regulations, but has not successfully permitted a project or is in the process of changing the regulations	Flag
D	State/County has a definition of geothermal resources, but does not have permitting regulations	Flag
E	State/County does not have any geothermal power regulations	Significant Barrier

Figure 4. Map of Permitting: State Regulatory Framework sub-attribute. This map represents an activity level of E, with a weighting factor of 2 in the Permitting attribute summary map.

3.1b.1 Federal Regulatory Framework Grading and Map

For this sub-attribute, experts did not feel that any of these grades would result in a *significant barrier*; however, grades C-E would raise *flags* and cause delays in project development. There are no currently *unallowed* grades for this sub-attribute.



A	BLM-administered mineral estate in an area with experience permitting geothermal exploration and development projects and BLM has an MOU with the state.	
B	BLM-administered mineral estate in an area with experience permitting geothermal exploration and development projects and BLM **does not have an MOU** with the state.	
C	BLM-administered mineral estate in an area **without experience** permitting geothermal exploration and development projects and BLM has an MOU with the state.	Flag
D	BLM-administered mineral estate in an area **without experience** permitting geothermal exploration and development projects and BLM **does not have an MOU** with the state.	Flag
E	No geothermal staff or funding	Flag

Figure 5. ***Map of Permitting: Federal Regulatory Framework Sub-attribute.*** This map represents an activity level of E, with a weighting factor of 2 in the Permitting attribute summary map. White areas indicate non-federal lands where this grade was not applicable. See Figure 6 for Permitting grades for these areas.

3.2 Barrier 2: Environmental Review Process

The environmental review process sub-attribute grades and map (Figure 6) address the environmental review process specific to the land where the project is located. Our grading focused on which states had environmental review processes, whether the project was on federal land and would require NEPA review, and the level of environmental review required. For mapping purposes we were only able to map whether the project was in a state with an environmental review process, on federal lands, or both. Projects that would require no additional environmental review beyond that required for permitting received an A, while projects that required one or two environmental review processes received a B and C, respectively.

Geothermal projects may have to go through the environmental review process as many as six times, and depending on the level of review (e.g., categorical exclusion (CX), environmental assessment (EA), environmental impact statement (EIS)) and complexity of the proposed activity, each review may take anywhere from one month to three or more years (Young et al., 2014). The map shown in Figure 6 highlights the areas where one or more environmental review processes are required. If more than one jurisdiction (e.g., state, federal) requires review processes, the process may be slowed; however, coordination among these regulators can help facilitate the review.

3.2.1 Environmental Review Process Grading and Map

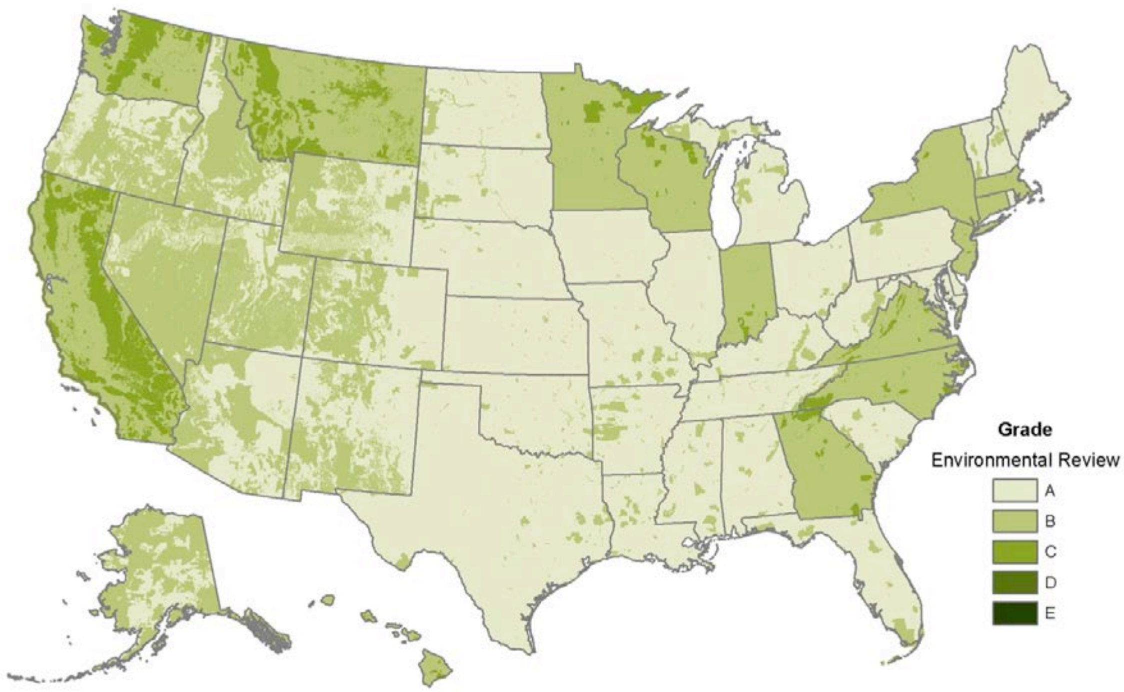
For this sub-attribute, experts stated that, while not *unallowed* by regulators, any project that has multiple jurisdictions of environmental review for projects that may have a significant impact on the environment would cause such time delays as to be rendered a *significant barrier* by developers. Additionally, just one of these two situations would cause *flags* (grades C and D). To understand if there would be significant impact to the environment, detailed local research would need to be conducted, and would be more akin to activity level D or above (A-D). Because we mapped this sub-attribute at activity level E, everything mapped as grades A-C. There are no *unallowed* grades for this sub-attribute.

3.3 Barrier 3: Ancillary Permits

The ancillary permit sub-attribute grades and map (Figure 7) address the number of permits the project may require not covered under geothermal-specific regulations in the state (e.g., exploration and well field drilling regulations). For mapping purposes we created a default power plant that was:

- Independent power producer-owned;
- 20-MW, air-cooled, binary power plant;
- 250°F (121°C) bottom-hole temperature;
- Requires rights-of-way for ingress and egress; and
- All waste disposal by pit, surface water discharge, or injection well.

We then reviewed information in the Regulatory and Permitting Information Desktop (RAPID) Toolkit for each of the twelve western states included in the RAPID Toolkit.[3] For the remaining states not included in the RAPID Toolkit, we used a default grade of C.



A	Project is not subject to any federal or state environmental review process for any permits required for the project. County approval assumed to take less than 180 days.	
B	Project is subject to **one** federal or state environmental review process for any permits required for the project. Federal review <12 months, State review <12 months	
C	Project is subject to **two** or more federal or state environmental review processes for any permits required for the project. Federal and State review will take 18 - 24 months.	Flag
D	Project is subject to **one** federal or state environmental review process for any permits required for the project and **has a significant impact on the environment**. Review will take > 24 months.	Flag
E	Project is subject to **two** or more federal or state environmental review processes for any permits required for the project and **has a significant impact on the environment**. Review will take >24 months and results in a *no-go* decision.	Significant Barrier

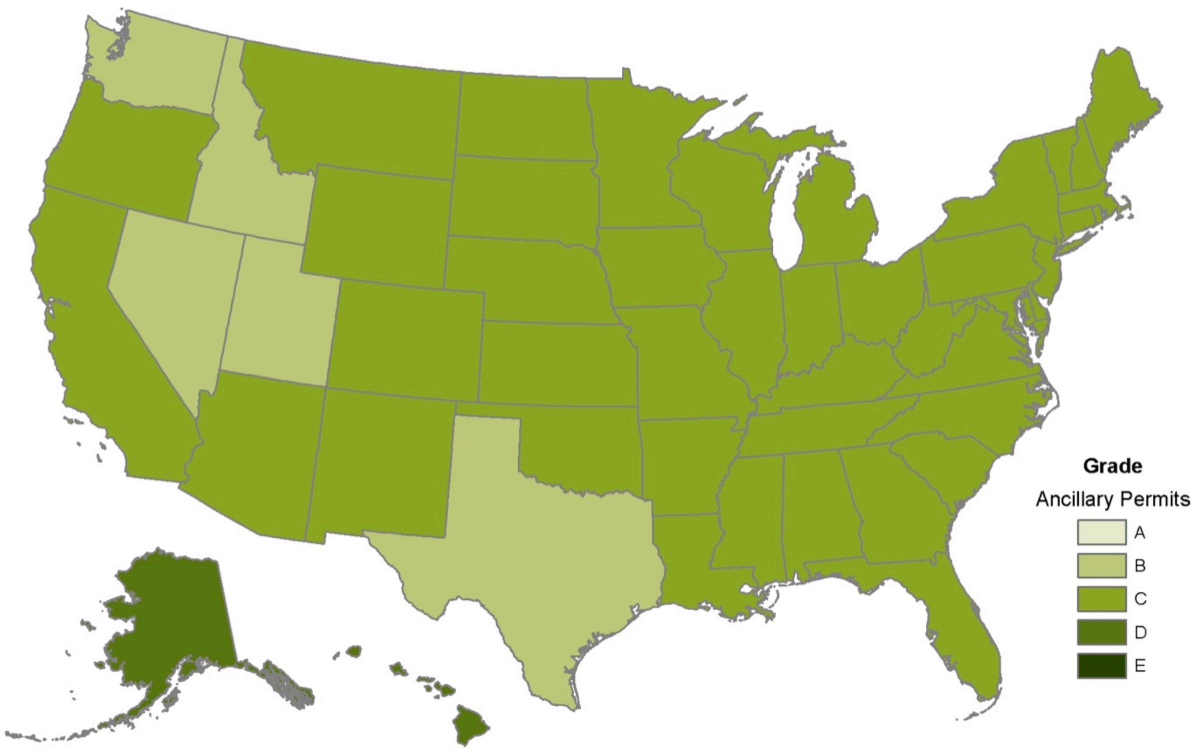
Figure 6. Map of Permitting: Environmental Review Process Sub-attribute. This map represents an activity level of E, with a weighting factor of 3 in the Permitting attribute summary map.

[3] The RAPID Toolkit includes geothermal specific information for Alaska, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Texas, Utah, and Washington.

Ancillary permits include air quality, water quality, waste disposal, highway and state land rights-of-way, and public utility commission approvals and siting processes. Ancillary permit approvals may require conducting studies, filing applications, public hearings, and other elements. The more time consuming the process is for receiving these permits, the greater the impact may be on project costs and timelines.

3.3.1 Ancillary Permits Grading and Map

Although there are no grade E situations mapped, this is due to the default power plant design. It is possible, depending on the power plant design, to have more than 10 permits—for example, for larger power plants or for flash plants. There are no *flags*, *significant barriers*, or *unallowed* grades for this sub-attribute.



	Ancillary Permits Required *In addition to those required for exploration, drilling and power production*	
A	Project requires <=4 permits	
B	Project requires 5-6 permits	
C	Project requires 7-8 permits	
D	Project requires 9-10 permits	
E	Project requires >10 permits	*(no flags/no-gos)*

Figure 7. Map of Permitting: Ancillary Permits Sub-attribute. This map represents an activity level of E, with a weighting factor of 1 in the Permitting attribute summary map.

4. Permitting Summary: Influence on Geothermal Development Timelines

This section summarizes the weighting of each permitting sub-attribute, the grading of the combined sub-attributes (i.e., attribute grade), and the cumulative map reflecting where geothermal projects could be expected to face permitting delays or uncertainty.

4.1 Summary of Sub-Attribute Weights, Grades, and Cumulative Permitting Attribute Map

Scores for each of the sub-attributes were weighted as follows and summed to create a Permitting attribute summary map.

1. Regulatory Framework (Weight = 2)
   a. State Regulatory Framework
   b. Federal Regulatory Framework
2. Environmental Review Process (Weight = 3)
3. Ancillary Permits (Weight = 1)

Table 4 summarizes the currently *unallowed*, *significant barrier*, and *flagged* grades for each of the permitting sub-attributes. The permitting analysis identified no *unallowed* sub-attribute grades, two developer-identified *no-go* sub-attribute grades, and seven *flagged* sub-attribute grades.

Table 4. Summary of Unallowed, Significant Barrier, and Flagged Permitting Sub-attribute Grades. Bolded sub-attribute grades have been mapped for this analysis. Sub-attribute grades listed in italics were unable to be mapped using publically available data; They may impact additional areas not shown on these maps, and may prevent development of additional geothermal potential not indicated in this analysis.

Sub-Attribute	Unallowed Grade(s)	Significant Barrier Grade(s)	Flagged Grade(s)
State Regulatory Framework	--	**E**	**C, D**
Federal Regulatory Framework	--	--	**C, D, E**
Environmental Review Process	--	*E*	**C**, *D*

The colors in the map (**Figure** 8) reflect a range of scores from 6 (all three sub-attributes graded as A) to 30 (all three sub-attributes graded as E). No *unallowed* and two developer-identified *significant barrier* situations occur for the permitting attribute.

The map shows the variability in ease of permitting in the western United States that cause time delays in project development. Because these sub-attributes were mapped at an activity level of E, there are no areas that show up as a permitting grade E on the map. As the activity level of individual projects increases with more project-level data, we anticipate the grade for some areas on the map to decrease. For example, for the environmental review process sub-attribute, grade C is the lowest grade currently mapped. However, if a developing project has a significant impact on the environment, the grade would be reduced to grade D or E (depending on the number of environmental review processes needed) which could create a *significant barrier*.

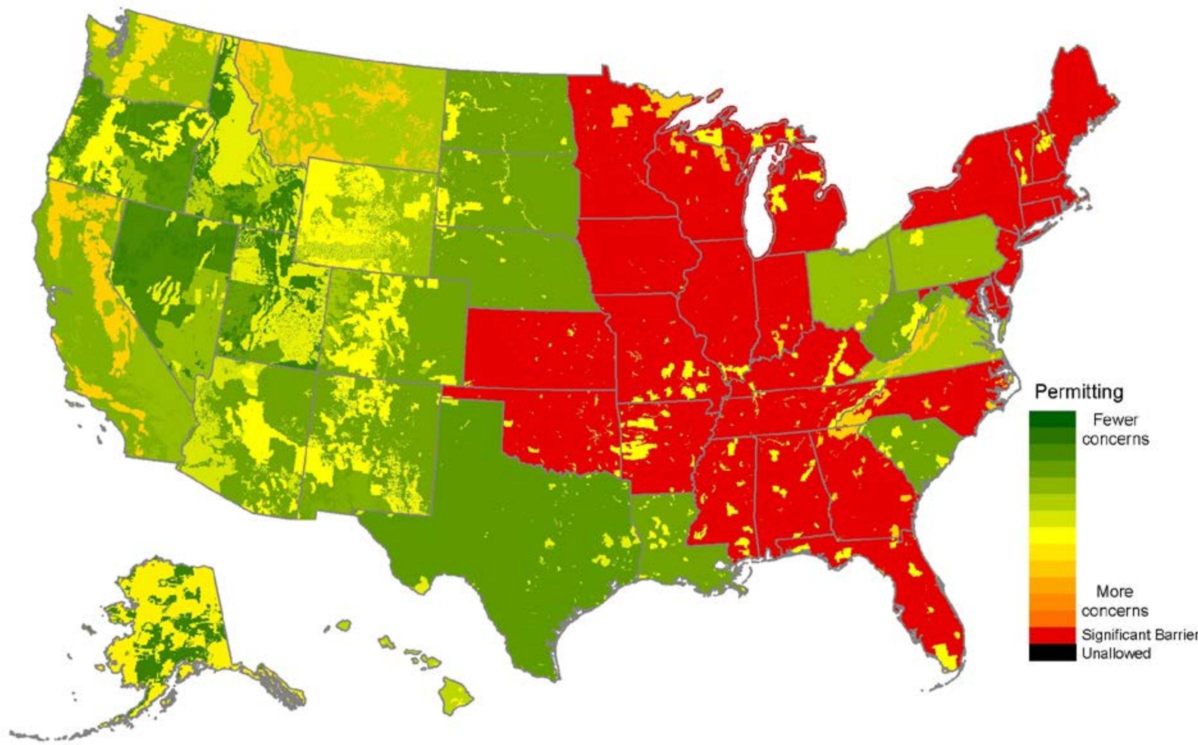


Figure 8. ***Permitting Attribute Summary Map.*** This map represents the summary of all of the Permitting sub-attributes. The colors in the map reflect a range of scores from 6 (all three sub-attributes graded as A) to 30 (all three sub-attributes graded as E). No *unallowed* situations occur for the permitting attribute**.**

5. Improvement Scenarios for Permitting Barriers

This section reviews the results of GETEM supply curve development and ReEDS U.S. electricity generation forecasting to understand baseline deployment scenarios (i.e., business as usual [BAU]) for geothermal resources as well as permitting improvement scenarios that may increase deployment of geothermal resources in future forecasts for 2030 and 2050.[4] We defined two improvement scenarios – one that improves timelines by two years; the other improves timelines by four years (Table 5). Examples of activities that can improve timelines include development of a centralized federal permitting office and development of CXs for geothermal akin to those already available for the oil and gas and mining industries.

[4] For a summary of caveats associated with the ReEDS model see Regional Energy Deployment System (ReEDS) Model Documentation: Version 2016 p. 7. http://www.nrel.gov/docs/fy17osti/67067.pdf.

Table 5. Improvement scenarios developed for ReEDs modeling

Scenarios	Potential timeline improvement scenario	Modeled project timeline
BAU	• Current delays caused by multiple environmental processes, delays in transmission studies and obtaining PPAs. • Timelines will increase over time with no mitigation	8 years
SCENARIO 1: Low Potential Improvement Case	• Centralized federal permitting offices speed up timelines due to familiarity of central staff with geothermal and its processes. • Coordinated state offices speed up state permitting timelines	6 years
SCENARIO 2: Disruptive Potential Improvement Case	• Low Improvement Case, PLUS: • CXs for: Up to 2 miles of roads (like USFS) New category of CXs for slim holes wells that penetrate the reservoir CX for wells analogous to oil and gas wells in Energy Policy Act (EPAct) of 2005 CX with reduced surface disturbance New technology to allow expansion of Temperature Gradient Wells CX In GETEM "Permitting Process Costs for Exploration Early Project Drilling" drops from $250k to $50k for all projects	4 years

5.2 Business as Usual Deployment

Before discussing potential improvement scenarios for geothermal deployment, this section provides an overview of the results of the ReEDS BAU scenario. The BAU scenario considers current and anticipated future conditions, assuming no drastic improvements in technical or non-technical barriers. The BAU scenario, therefore, does not consider any permitting improvements and serves as a baseline to understanding the increased deployment in the potential improvement scenarios.

The ReEDs model assumes a current (2016) installed capacity of 2,685 MW. Under the BAU scenario, the model forecasts total deployed capacity for identified and undiscovered hydrothermal geothermal resources to be 4,109 MW by the year 2030 and 5,952 MW by the year 2050, as shown in Figure 9.

In addition, the ReEDS model forecasts larger levels of geothermal deployment due to enhanced geothermal systems in scenarios analyzing improved technology impacts. These scenarios deploy cost-competitive enhanced geothermal systems beginning in 2024. For the impact of timeline improvements under these scenarios, see Young et al., 2017.

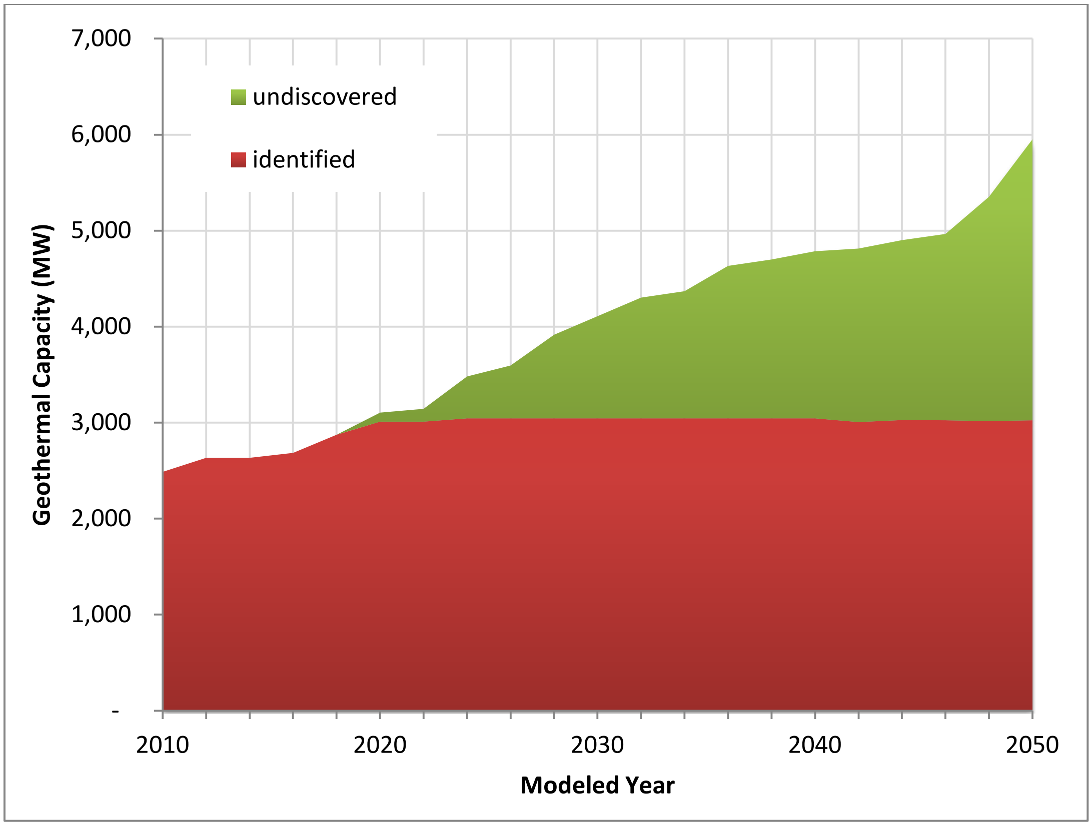


Figure 9. ***B Deployment Curve for Hydrothermal Geothermal Resources.*** The graph reflects ReEDS model outputs for forecasted hydrothermal geothermal resource deployment through 2050 under BAU assumptions.

5.3 Low Potential Improvement Scenario: Centralized Federal Permit Office and State Permit Coordination Offices

Centralized federal permit offices and state permit coordination offices can be an effective tool for coordinating the permits and environmental reviews required to explore and develop geothermal resources. Various federal and state programs already exist to coordinate review and approval of permits for oil and gas, renewable energy projects, or large infrastructure projects generally (Levine et al., 2013). At the federal level, EPAct 2005 §365 established a Pilot Project to Improve Federal Permit Coordination for oil and gas permitting and environmental review on BLM managed federal land. The pilot project created seven pilot offices in Colorado, Montana, New Mexico, Wyoming, and Utah, which were overseen by BLM field managers within each district (EPAct § 365 (c)(2) & (d)). The pilot program began with development of a Memorandum of Understanding (MOU) between the Department of Interior (BLM, U.S. Fish and Wildlife Service, Bureau of Indian Affairs, Minerals Management Service, Bureau of Reclamation), the USFS, U.S. Army Corp of Engineers, Environmental Protection Agency, U.S. Department of Agriculture, and State Governors and subsequent staffing of pilot offices with staff from the MOU agencies (EPAct § 365 (b) and (c)).

A 2008 report analyzing the initial results from the first two years of the pilot program (*see* BLM 2008) found a number of techniques employed that assisted in reducing permitting timelines, including:

- Reduced duplication in effort through better federal and state agency coordination and data sharing
- Improved efficiency through face-to-face communication resulting from co-location of agency staff
- Improved efficiency in NEPA processing timelines resulting from interagency coordination, greater use of CXs, and expanded use of strategies to process more permit approvals through a single NEPA action (BLM, 2008).[5]

At the state level, permit coordination offices have taken various forms with various success rates depending on the design and implementation of the program (Levine et al, 2013). However, generally state permit coordination offices provide a number of advantages, including:

- A central point of contact for the developer to ask questions surrounding the project
- Pre-application meetings that assist in identifying the permits and regulatory approvals necessary to develop the project
- Reduction in duplication of efforts
- Data and information sharing between multiple agencies. (Levine et al, 2013).

This improvement scenario analyzes the impacts of the creation of a centralized federal permitting office in the Western United States for geothermal development and an expanded use of state permit coordination offices. Benefits of a centralized federal permitting office for geothermal could include:

- Create efficiencies by repetition and development of expertise by core geothermal staff
- Allow for efficient use of BLM resources by reducing duplication of staff capabilities (e.g. instead of training one person in 5 areas, train a few employees only in geothermal)
- Create teams with common skills/capabilities to accommodate staff unavailable due to onsite work travel, vacation, and holiday schedules
- Develop a dedicated geothermal staff and skills that would allow for more efficient completion of geothermal-specific projects (e.g. updating regulations, agency orders, etc.).

Overall, we estimate that a combination of a geothermal centralized federal permitting office and expansion of state permit coordination offices could reduce timelines from the current GETEM estimate of eight years to six years for hydrothermal resources. Figure 10 shows how these timeline reductions may increase the deployment of identified and undiscovered geothermal resources as modeled through ReEDS.

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[5] The two-year review found that NEPA processing times decreased 25% (BLM, 2008).

Under the low improvement scenario, the ReEDS model forecasts total deployed capacity for identified and undiscovered hydrothermal geothermal resources to be 4,313 MW by 2030 and 6,719 by 2050 – a 13% (768 MW by 2050) improvement over the BAU scenario.

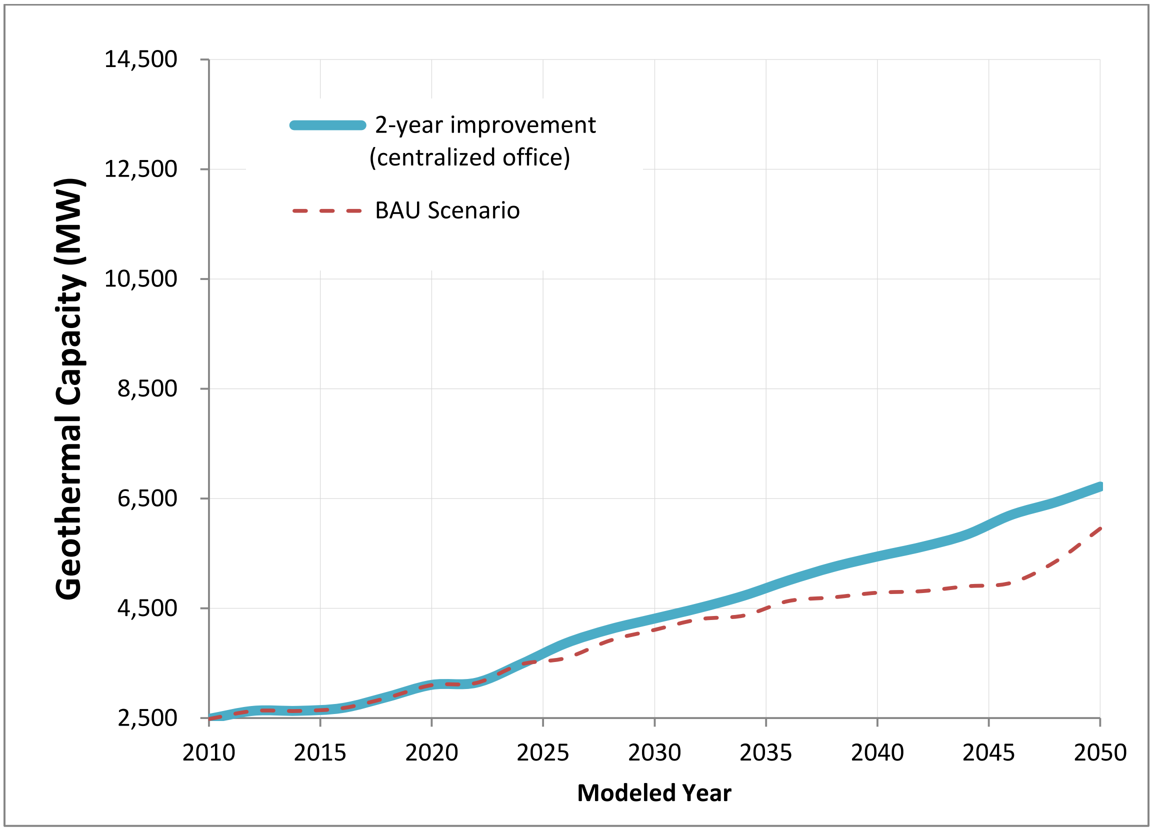

Figure 10. ***Low Potential Improvement Scenario Deployment Curve for Hydrothermal Geothermal Resources.*** The graph reflects ReEDS model outputs for forecasted hydrothermal geothermal resource deployment through 2050 under a low improvement scenario that includes the creation of a centralized federal geothermal permitting office and expanded use of state permitting coordination offices. The graph compares the results of the low potential improvement scenario to the BAU scenario.

Additional scenarios were run for the GeoVision study combining permitting improvements with other improvements (e.g., land access, market and/or technology improvements) (Young et al., 2017).

5.4 Disruptive Potential Improvement Scenario: Expansion of Current Geothermal Categorical Exclusions

As discussed in section 3.2 Permitting: Environmental Review Process, geothermal projects on federally managed land and/or receiving federal funding may be subject to an environmental review process under NEPA as many as six times from the land use planning phase through utilization of the geothermal resource. However, the type of review process required (e.g., CX, EA, EIS) may have as significant of an impact on overall geothermal development timelines as the number of times the project must complete an environmental review process. For example, CXs[6] take significantly less time to complete than an EA or an EIS, with CXs taking approximately 2 months to complete for a geothermal project, while the EAs and EISs take approximately 10 months and 25 months respectively (Young et al., 2014).

Currently, BLM regulations include one CX applicable to geothermal development, which applies to geothermal exploration operations permitted under a Notice of Intent to Conduct Geothermal Resource Exploration Operations[7] as long as the exploration operations include no temporary or new road construction (DOI 516 DM 11.9). The BLM uses this CX for all geophysical activities and temperature gradient wells, where the activity does not include new surface disturbance (including new well pads) and the activity does not trigger any extraordinary circumstances[8] preventing usage of the CX.

CXs may also be authorized legislatively through an act of Congress, in which case the terms of the legislation dictate how to apply the CX (43 CFR §46.205). In 2005, Congress passed legislative CXs for oil and gas in Section 390 of EPAct 2005[9]. The §390 oil and gas CXs include:

- Individual surface disturbance of less than 5 acres so long as the total surface disturbance on the lease is not greater than 150 acres and site-specific analysis in a document prepared pursuant to NEPA has been previously completed
- Drilling an oil and gas well at a location or well pad site at which drilling has occurred previously within five years prior to the date of spudding the well
- Drilling an oil and gas well within a developed field for which an approved land use plan or any environmental document prepared pursuant to NEPA analyzed such drilling as a

[6] A categorical exclusion is a "category of actions which do not individually or cumulatively have a significant effect on the human environment and which have been found to have no such effect in procedures adopted by a Federal agency…and for which, therefore, neither an environmental assessment nor an environmental impact statement is required" (40 CFR §1508.4).
[7] Exploration operations are defined as "…any activity relating to the search for evidence of geothermal resources, where you are physically present on the land and your activities may cause damage to those lands. Exploration operations include, but are not limited to, geophysical operations, drilling temperature gradient wells, drilling holes used for explosive charges for seismic exploration, core drilling or any other drilling method, provided the well is not used for geothermal resource production." 43 CFR §3200.1
[8] Extraordinary circumstances are a list of resources that when significantly impacted prevent the use of the categorical exclusion. BLM extraordinary circumstances that may prevent the use of a CX, include significant impacts on: environmentally sensitive resources such as historic or cultural resources; park, recreation or refuge land; wilderness areas; wild or scenic rivers; national landmarks and national monuments; migratory birds and species listed, or proposed to be listed, on the list of endangered or threatened species; and activities with a highly uncertain and potentially significant environmental effects or involve unique or unknown environmental risks. For a complete list of BLM extraordinary circumstances see 43 CFR §46.215.
[9] The EPAct §390 CXs do not require review for extraordinary circumstances (see Levine and Young, 2014).

reasonably foreseeable activity, so long as such plan or document was approved within five years prior to the date of spudding the well

- Placement of a pipeline in an approved right-of-way corridor, so long as the corridor was approved within five years prior to the date of placement of the pipeline
- Maintenance of a minor activity, other than any construction or major renovation of a building or facility EPAct § 90.

However, in the draft version of §390 originating out of the Committee on Natural Resources of the U.S. House of Representatives (109th Congress H.R. 6 § 2055) seven CXs were proposed to apply to exploration or development of a "domestic Federal energy source" which included four CXs applicable to geothermal development:

- Geophysical exploration that does not require road building
- Individual surface disturbance of less than 5 acres
- Placement of a pipeline in an approved right-of-way corridor
- Maintenance of a minor activity, other than any construction or major renovation of a building or facility.

During conference committee between the House of Representatives and the Senate, however, the CXs were limited to those activities for the purpose of exploration or development of "oil and gas," thus removing geothermal exploration and development from the enacted version (Oversight Hearing, W. Jackson Coleman).

This disruptive improvement scenario analyzes the potential impact of expanding CXs for geothermal exploration at both the legislative and/or administrative level in combination with the low improvement scenario of centralized federal permitting offices and coordinated state permit offices. These CXs may include:

- Geothermal CXs analogous to the oil and gas CXs authorized under EPAct 2005, which were originally drafted to apply to geothermal exploration and parts of which have since been included in more recent bills such as S. 562, 114th Cong. (2015).
- Construction of up to one mile of low standard roads or minor repair to existing roads to reach sites for drilling core holes, temperature gradient wells, and seismic shot holes on BLM managed federal land.

Overall, we estimate that a combination of a geothermal centralized federal permitting office, expansion of state permit coordination offices, and an expansion of the existing CXs could reduce development timelines from the current GETEM estimate of eight years to four years for hydrothermal resources. In addition, CXs for geothermal exploration and development have the potential to decrease the cost and time associated with geothermal exploration and resource confirmation. We estimate that the expansion of existing CXs could increase the rate of discovery for undiscovered geothermal resources from a BAU of 1% to 3%, due to the time saved by utilizing CXs (approximately 2 months to process) as opposed to EAs (approximately 10 months to process). Figure 11 shows how these timeline reductions may increase the deployment of identified and undiscovered geothermal resources as modeled through ReEDS.

Under the disruptive improvement scenario, the ReEDS model forecasts total deployed capacity for identified and undiscovered hydrothermal geothermal resources to be 6,638 MW by 2030 and 12,869 MW by 2050 – a 116% (6,918 MW) increase over the BAU scenario.

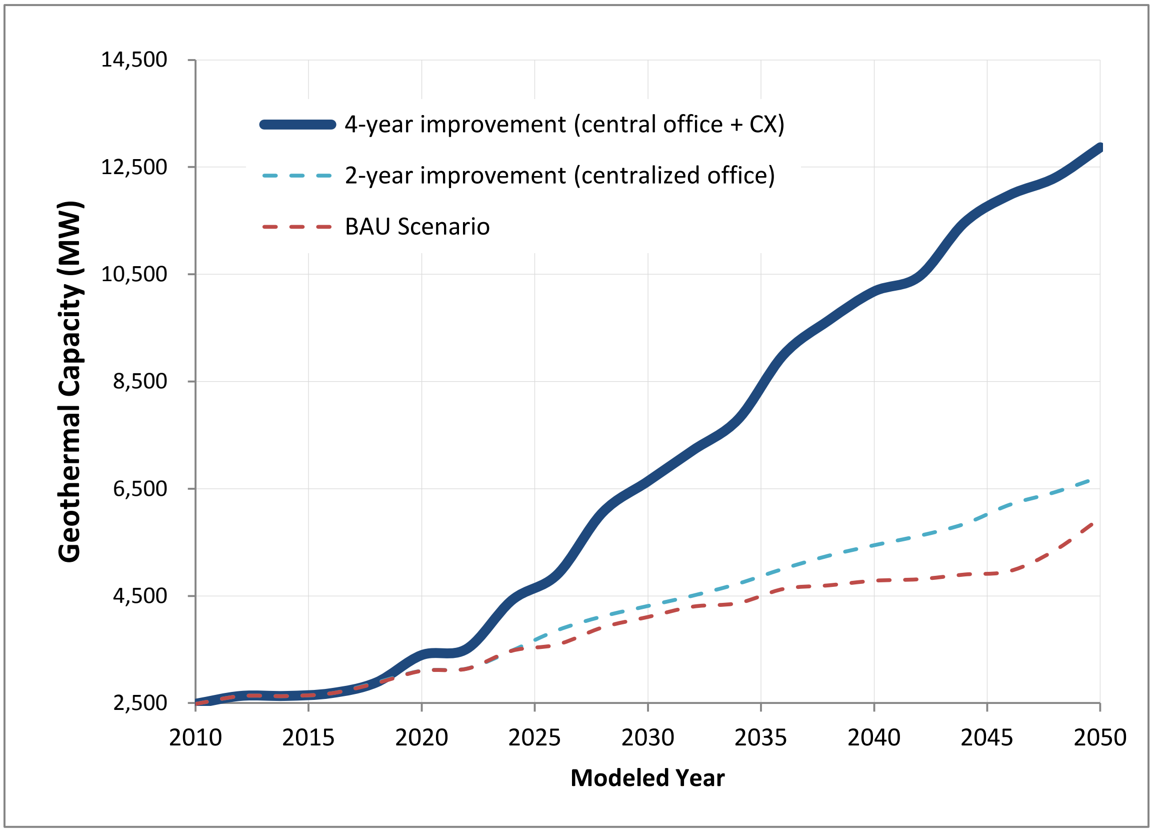

Figure 11. ***Dispurive Potential Improvement Scenario Deployment Curve for Hydrothermal Geothermal Resources.*** The graph reflects ReEDS model outputs for forecasted hydrothermal geothermal resource deployment through 2050 under a disruptive potential improvement scenario that includes the expanded use of CXs coupled with the creation of a centralized federal geothermal permitting office and expanded use of state permit coordination offices. The graph compares the results of the disruptive potential improvement scenario to the BAU and low potential improvement scenarios.

Additional scenarios were run for the GeoVision study combining permitting improvements with other improvements (e.g., land access, market and/or technology improvements) (Young et al., 2017).

6. Conclusion

This paper highlighted many of the identified geothermal barriers associated with permitting timelines and delays for geothermal development. While our research and analysis did not identify any permitting barriers that prevented development (i.e., where development is unallowed), we did find two situations that our BET identified as a significant barrier potentially preventing development at a site. First, the BET stated that where a state or county does not have geothermal power regulations in place this would be a significant barrier that may deter a developer from pursuing the proposed geothermal project. Second, the BET stated that where a project is subject to two or more federal and/or state environmental review processes for any permits required for the project and the project has a significant impact on the environment this may prevent a developer from pursuing the proposed geothermal project.

While permitting timelines and delays have not historically prevented geothermal development entirely, delays can sometimes stall development to the point where it would have the same effect. Our market forecast modeling results suggest that reducing permitting timelines could lead to substantial additional geothermal deployment. The model results forecast that reducing timelines by 2 years –for example, with the creation of a centralized federal geothermal permitting office and utilization of state permit coordination offices – could result in deployment of an additional 204 MW by 2030 and 767 MW (13%) by 2050 when compared to the BAU scenario. The model results forecast that reducing timelines by 4 years – for example, by the expansion of existing CXs coupled with the creation of a centralized federal geothermal permitting office and utilization of state permit coordination offices – could result in deployment of an additional 2,529 MW of geothermal capacity by 2030 and 6,917 MW (116%) of geothermal capacity by 2050 when compared to the BAU scenario.

With technology improvements, we see permitting improvements having a larger impact on deployment with large levels of enhanced geothermal systems occurring due to cost-competitive EGS costs beginning in 2024. For the comprehensive report, see Crossing the Barriers: An Analysis of Non-technical Barriers to Geothermal Development and Potential Improvement Scenario Analyses for the DOE GeoVision Study. (Young et al. 2017, NREL Report Forthcoming).

Acknowledgements

This work was authored by employees of the Alliance for Sustainable Energy, LLC, and supported by the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy (EERE), Geothermal Technologies Office (GTO) under Contract No. DE-AC36-08-GO28308 with the National Renewable Energy Laboratory.

The authors wish to thank Donna Heimiller for developing all of the GIS work and maps used in this analysis, Chad Augustine for developing the multiple supply curves, and to Jonathan Ho for running the ReEDs analyses.

We would also like to thank the BET members, including Charlene Wardlow (Ormat), David Batts (EMPSi), Dwight Carey (EMA), Laurie Hietter (Panorama Environmental), Paula Blaydes (Blaydes and Associates), Pierre Audinet (World Bank), Ben Matek and Karl Gawell (GEA), Casey Strickland (U.S. DOE), Lorenzo Trimble (BLM), and Jeff Jones (USFS), and all others who provided comment and input during the development of this analysis, including Colin Williams (USGS), Andy Sabin (Navy GPO), Randy Peterson and Josh Nordquist (Ormat), Scott Nichols (US Geothermal), Daniel Fleishmann (ENEL Green Power), Andy Van Horn (Van Horn Consulting), and the DOE Geothermal staff and GeoVisionary Team for their feedback and guidance throughout the process. We also thank the NREL review team, including Kendra Palmer, Emily Newes, Jeff Logan, David Mooney, and Bud Johnston.

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