GeoVision Analysis Supporting Task Force Report: Barriers

An Analysis of Non-Technical Barriers to Geothermal Deployment and Potential Improvement Scenarios

Katherine Young, Aaron Levine, Jeff Cook,
Donna Heimiller, and Jonathan Ho

National Renewable Energy Laboratory

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Forward

This report describes research and analysis performed in support of the U.S. Department of Energy Geothermal Technologies Office for its Geothermal Vision Study. A summary of the study is captured in DOE's report, *GeoVision: Harnessing the Heat Beneath Our Feet* (DOE 2018) and included ground-breaking, detailed research on geothermal technologies. The study projects and quantifies the future electric and nonelectric deployment potentials of these geothermal technologies within a range of scenarios in addition to their impacts on U.S. jobs, the economy, and environment. Coordinated by the U.S. Department of Energy Geothermal Technologies Office, the Geothermal Vision Study development relied on collecting, modeling, and analyzing robust data sets through seven national laboratory partners that were organized into eight technical task force groups. These task forces and their respective principal leading national laboratory are listed in Table F-1. The table also provides a guide to the final research documents produced by each *GeoVision* task force. In most cases, these were prepared as laboratory reports, and they are referenced accordingly. Consult these external reports for detailed discussions of the topics contained within, which form the basis of the *GeoVision* analysis.

Table F-1. Guide to Technical Research Documents Providing the Basis of the *GeoVision* Analysis

***GeoVision* Task Force**	**Lead National Laboratory**	**Report Number/Citation**
Exploration and Confirmation	Lawrence Berkeley National Laboratory	LBNL-2001120 (Doughty et al. 2018)
Potential to Penetration	National Renewable Energy Laboratory	NREL/TP-6A20-71833 (Augustine et al. 2018)
Thermal Applications: Direct Use	National Renewable Energy Laboratory	NREL/TP-6A20-71715 (McCabe et al. 2018)
Thermal Applications: Geothermal Heat Pumps	Oak Ridge National Laboratory	ORNL/TM-2017/502 (Liu et al. 2018)
Reservoir Maintenance and Development	Sandia National Laboratories	SAND2017-9977 (Lowry et al. 2017a)
Hybrid Systems	Idaho National Laboratory	INL/EXT-17-42891 (Wendt et al. 2018)
Institutional Market Barriers (this report)	National Renewable Energy Laboratory	NREL/PR-6A20-71641 (Young et al. 2018)
Social and Environmental Impacts	Lawrence Berkeley National Laboratory	NREL/TP-6A20-71933 (Millstein et al. 2018)

Acknowledgments

ACKNOWLEDGMENTS

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 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), 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 (U.S. 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 communications and review team, including Rob Leland, Dan Bilello, Jaquelin Cochran, Jeffrey Logan, Eric Lantz, and Linh Truong.

Acronyms

ACRONYMS

ATB	Annual Technology Baseline
BAU	business-as-usual
BET	barriers expert team
BLM	U.S. Bureau of Land Management
BTI	Barrier Technology Improvement
CEQA	California Environmental Quality Act
CPUC	California Public Utilities Commission
CSP	concentrating solar power
CX	categorical exclusion
dGeo	Distributed Geothermal Market Demand Model
DoD	U.S. Department of Defense
DOI	U.S. Department of Interior
EA	environmental assessment
EGS	enhanced geothermal system
EIA	U.S. Energy Information Administration
EPAct	Energy Policy Act of 2005
ESA	environmentally sensitive area
EXDR	exploration/confirmation drilling
FITs	feed-in-tariffs
GEA	Geothermal Energy Association
GeoRePORT	Geothermal Resource Portfolio Optimization and Reporting Technique
GETEM	Geothermal Electricity Technology Evaluation Model
GHMA	general habitat management area
GPO	Navy Geothermal Program Office
GTO	Department of Energy’s Geothermal Technologies Office
GVS P2P	Electric Sector Potential to Penetration
ICO	installation commanding officers
IMLUCC	Interagency Military Land Use Coordinating Committee
IRT	Improved Regulatory Timeline
ITC	investment tax credit
JEDI	Jobs and Economic Development Impact
LCOE	levelized cost of energy

Acronyms

ACRONYMS (cont.)

LTPP	Long Term Procurement Planning
MOU	memorandum of understanding
MW	megawatt
MWe	megawatt electric
kWe	kilowatt electric
MWh	megawatt hours
MMBTU	one million British Thermal Units
NAWS	Naval Air Weapons Station
NEPA	National Environmental Policy Act
NF EGS	near-field enhanced geothermal system
NOI	Notice of Intent
NREL	National Renewable Energy Laboratory
NVNM	Newberry Volcano National Monument
O&M	operations and maintenance
PDE	pre-drilling exploration
PEIS	Programmatic Environmental Impact Statement
PHMA	priority habitat management area
PPA	power purchase agreement
PP	power plant
PTC	production tax credit
PV	photovoltaics
RE	renewable energy
ReEDs	Regional Energy Deployment System Model
RPS	renewable portfolio standards
SEAT	Socio-Economic Assessment Tool
SHPO	State Historic Preservation Office
STIM	stimulation
TAT	Technical Assessment Tool
TGH	temperature gradient hole
USGS	U.S. Geological Survey
VRE	variable renewable energy
WFDR	well-field drilling

Key Messages

- **Flat line** in geothermal **deployment** in recent years **may be due to institutional/soft-cost** (and not technical cost) barriers. Overcoming these barriers could lead to increased deployment slopes.
- The **geothermal resource supply curve is decreasing** due to growing environmental and land-use restrictions. Technology improvements and mitigation techniques may be able to reduce the impact these restrictions have on future geothermal development.
- **Permitting and land access challenges** can impact accessibility and development timeframes, **severely impacting deployment** potential. Modeling suggests these challenges reduce deployment by more than 50% in the BAU case and by 15% in the Barrier Technology Improvement (BTI) case.
- Well-designed policies and incentives can drive deployment:
    - **Set-asides** – Historical set-asides have allowed for deployment of non-economically competitive technologies (e.g., solar); the model demonstrates similar impact if geothermal set-asides were implemented.
    - **Tax credits** – Historical PTC has driven deployment of (cost-competitive) wind. Geothermal project timelines are too long to take advantage of this structure (as implemented). Historical oil and gas tax credits are exploration related and help to lower upfront risk.
    - **RD&D funding** – Historical (worldwide) government research funding in solar has helped drive reduction of solar LCOE, raise social acceptance of solar, and encourage policy/incentive development for increased solar deployment. Historical high geothermal budgets (e.g., 1980s) drove similar increases in geothermal deployment.

Key Messages (continued)

- Benefits of geothermal (e.g., economics, jobs, land use) relative to other technologies suggest states and **communities would benefit from increased geothermal deployment**.

- Local and federal **economic paybacks are high** compared to other renewables, so states that support development of geothermal will have greater economic benefit:
  - Local, full-time, living wage jobs Federal, state, and local annual royalties back into communities—if developed on state or federal land
  - High O&M spending into local communities Federal and state taxes, so geo generation produces more tax income for states and federal government.

- **Environmentally friendly** – low greenhouse gas emissions, small footprint, low water use, etc.
- The geothermal industry could benefit from improved, targeted marketing and advocacy to improve the community, market, and socio-political acceptance of geothermal development.

Contents

To use the links in this slide deck, view in presentation mode

1.1 DOE GeoVision Study

In 2015, the DOE Geothermal Technologies Office (GTO) began a vision study (GeoVision) to conduct analysis of potential growth scenarios across multiple market sectors (e.g., geothermal electric generation, commercial and residential thermal applications) for 2030 and 2050.

The work was divided into task forces led by GTO team members. The research for one task force, institutional barriers, is being led by the National Renewable Energy Laboratory (NREL). The institutional barriers task force is charged with analyzing non-technical barriers that create delays, increase risk, or increase the cost of project development. These non-technical barriers include **land access**, **permitting**, access to **transmission**, and **market conditions** that may create challenges in developing a power purchase agreement (PPA).

In 2016, we analyzed the barriers to deployment and the impact on available resources. These impacts were modeled in the Regional Energy Deployment System (ReEDs) model to estimate future geothermal deployment under these business-as-usual (BAU) conditions.

In 2017, we developed potential improvement scenarios and ran these scenarios in the ReEDs model to understand the potential impact these improvements could have on geothermal deployment.

This presentation includes the results of these analyses and lists potential activities for increasing geothermal deployment in the United States.

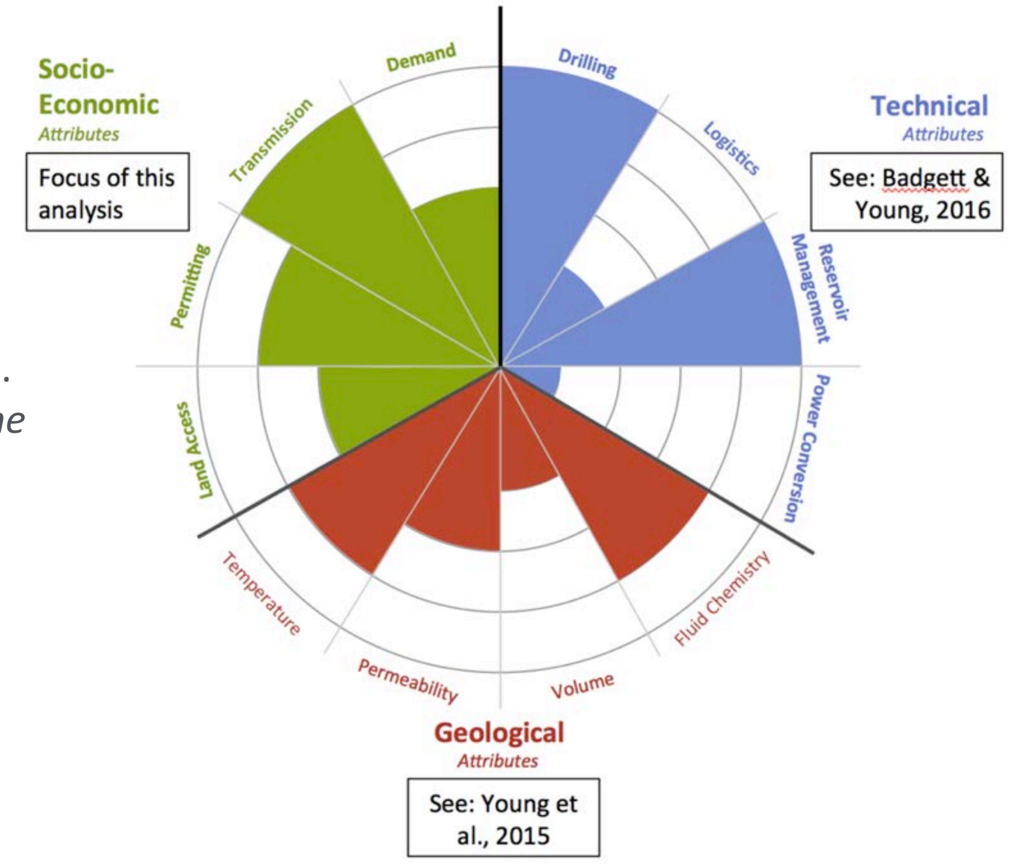
1.2 Previous Barriers Analyses & Tools

Non-Technical Barriers of Geothermal Projects *Imolauer and Ueltzen (2015)*	• Developed system that allows for evaluation and analysis of the economic, legal, and administrative conditions in countries for implementation of geothermal energy projects. • No details were provided describing the system or the analysis, but authors reported that it yielded non-technical (and non-geological) barriers that substantially inhibit further development of the geothermal market and, correspondingly, the investment volume. • Conclusion: Systematic analysis of non-technical conditions is important in identifying barriers that can have a substantial impact on the economic success of a project.
U.S. Department of Energy's Regulatory and Permitting Information Desktop (RAPID) Toolkit *http://openei.org/wiki/RAPID*	• Web-based, interactive database with two main tools: ○ Regulatory and Permitting database describing the process for developing geothermal projects in the United States and in 12 western states ○ National Environmental Policy Act of 1969 (NEPA) database that catalogued NEPA-related environmental analysis for geothermal projects.
Geothermal Permitting and NEPA Timelines *Young et al. (2014)*	• Analysis of timelines for specific types of environmental analysis for leasing and permitting under NEPA. • Details total number of times a geothermal project may need to complete the NEPA review process during project development and how long those reviews may take for each type of permit. • Identifies factors that increase NEPA review timelines and discusses proven and potential strategies for lowering the amount of time necessary to navigate the NEPA process.
Doubling Geothermal Generation Capacity by 2020: A Strategic Analysis *Wall and Young (2016)*	• Reviews 6.4 GW of geothermal projects in development in the United States from 2012-2015 as reported by the Geothermal Energy Association (GEA). Estimates foresee that these projects have the potential to more than double the 3.8 GW of current geothermal capacity in the United States. • Identifies which projects were likely to come online by 2020 (784 MW) and which had too many barriers to be completed so quickly. • Over half of the projects analyzed are in early stages of development and therefore still face barriers of development risk and uncertainty outside specific barriers explored in analysis. • Largest barriers identified include market barriers (PPA acquisition), permitting (including land access), transmission, and financing. • Only 5.3% (177 MW) show the resource to be the main barrier slowing or preventing development.

2.1 GeoRePORT Overview

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.
- Is particularly useful for describing early-stage exploration projects.
- Is unique in providing a detailed system for reporting both the **resource grade** and the **project readiness level.** *The analysis conducted for GeoVision discusses only **resource grade** and not project readiness levels.*
- Is comprised of three assessment tools: **Geological**, **Technical**, and **Socio-Economic**. *The GeoVision analysis focuses on use of the **socio-economic** grade assessment tool to analyze institutional barriers.*
- Each of the assessment tool's resource grades are divided into attributes and sub-attributes that describe the characteristics that contribute to feasibility of project development (see figure).



2.1 Using GeoRePORT for Barriers Analyses

BOX 1: Example SUB-ATTRIBUTES

The **Land Access** attribute has six sub-attributes:

1. Cultural and tribal resources
2. Environmentally sensitive areas
3. Biological resources
4. Land ownership
5. Federal and state lease queue
6. Proximity to military installation

- The Socio-Economic Assessment Tool (SEAT) encompasses four attributes: Land Access, Permitting, Transmission, and Market.
- Each of these attributes include sub-attributes (see box 1).
- Each sub-attribute has definitions of grades (see box 2), which, when combined, provide a character grade for each attribute.
- Each sub-attribute is given a weight, and the total attribute-weighted sum is calculated.

BOX 2: Example SUB-ATTRIBUTE GRADES

A geothermal project may be reported with one of the following Biological Resources Sub-Attribute Grades:

A. No biological resource issues present in the area

B. Manageable biological resource issues (nearby species of concern); developers may expect a 3-6 month regulatory staff review

C. Biological concerns, such as nearby migratory birds, bald/golden eagles, and or endangered or threatened species, or if the resource is located in a Sage Grouse General Habitat Management Area (GHMA); developers may expect a 6-12 month regulatory staff review and resolution

D. Difficult biological issues, such as a Sage Grouse Priority Habitat Management Areas (PHMA); not likely to resolve, 1-2 years or longer if resolution possible.

E. Project is located in a Sage Grouse PHMA Focal Area

2.1 Using GeoRePORT for Barriers Analyses

STEP 1: Identify market barriers (sub-attributes) and weight them according to impact

Barriers (Sub-Attributes)

1. Market demand
2. Price of electricity
3. Policies
4. Incentives

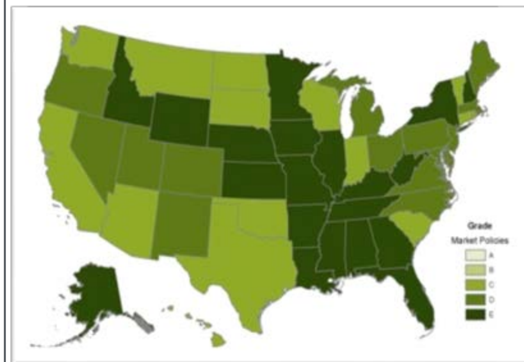
STEP 2: Develop grading system for the market attribute and each sub-attribute

EXAMPLE: Policy Sub-Attribute Grades

Grades	Description
A	Feed-in tariff for geothermal (standard offer contracts)
B	Interconnection set-aside or RPS or state purchase requirement **specific for geothermal**
C	State renewable purchasing requirements or RPS - **not preferential to a particular renewable**
D	State purchasing requirements or RPS - **with preferential consideration or set-asides for non-geothermal renewables**
E	No policies beneficial to renewables (No RPS)

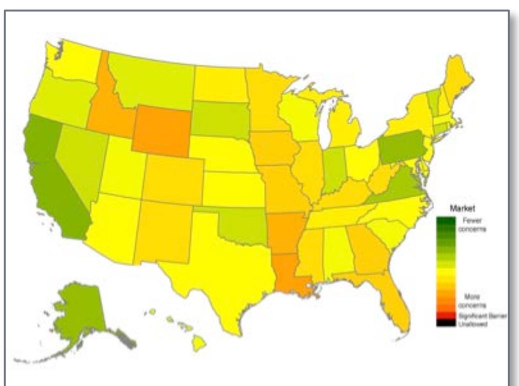
STEP 3: Collect and/or develop data to create maps of each sub-attribute

EXAMPLES: Figures 4-7



STEP 4: Combine all attributes into a single attribute summary map

EXAMPLE: Figure 8



STEP 5: Identify thresholds (unallowed, significant barrier) for each sub-attribute

EXAMPLE: Table 4

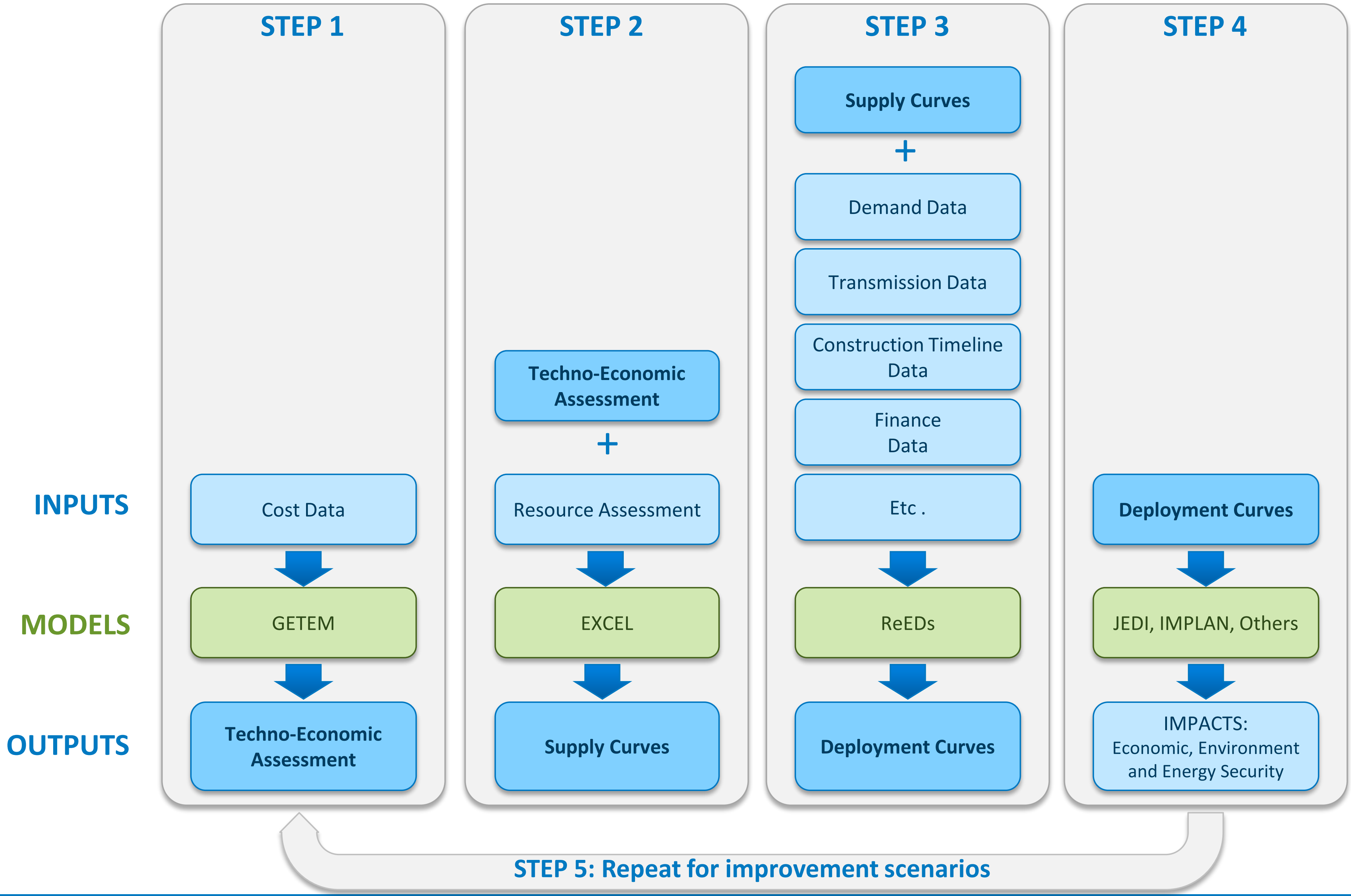
Sub-Attribute	Unallowed Grade(s)	Significant Barrier Grade(s)	Flagged Grade(s)
Market Demand	--	--	**D, E**
Price of Electricity	--	--	--
Policies	--	--	--
Incentives	--	--	--

STEP 6: Estimate potential geothermal deployment for various market scenarios

*EXAMPLE: Table 5*RPS

Scenarios	Potential improvement scenario
BAU	• Deployment based on current market conditions (current policies/incentives).
SCENARIO 1: Renewables	• Increased State renewable standards
SCENARIO 2: Baseload	• Baseload set-aside, or • Baseload tax incentive, or • Integration charge for VREs
SCENARIO 3: Geothermal	• Geothermal set-aside, or • Geothermal tax incentive

2.2 Market Deployment Analyses

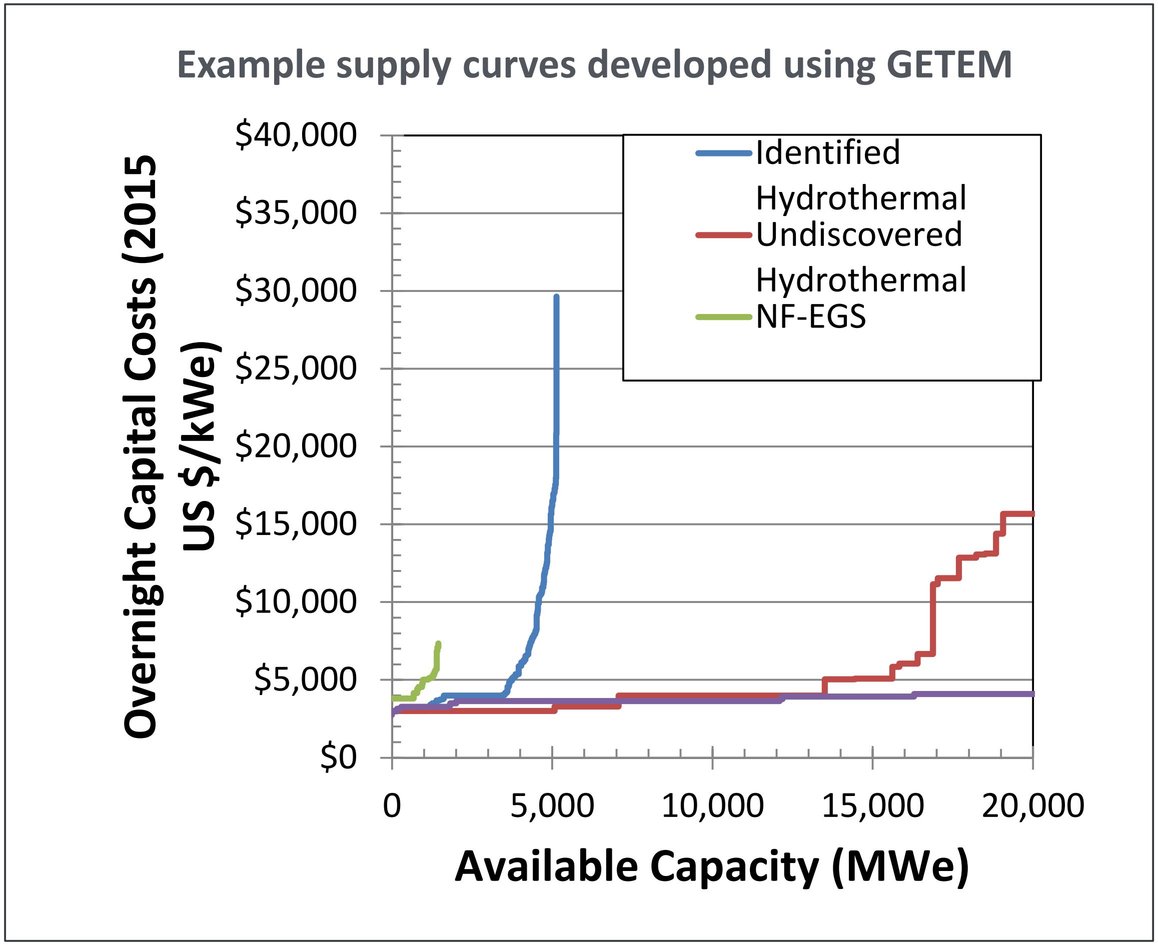


2.2 GETEM Tool Overview

The Geothermal Electricity Technology Evaluation Model (GETEM) is an Excel-based tool used to estimate the levelized cost of energy (LCOE) for definable geothermal scenarios.

GETEM only considers electric power generation and does not provide assessment capabilities for geothermal direct-use or geothermal heat pumps.

GETEM inputs were utilized in the GeoVision to develop supply curves for deployable geothermal resources.



For more information about GETEM, see: https://energy.gov/eere/geothermal/geothermal-electricity-technology-evaluation-model

2.2 ReEDs Tool Overview

The Regional Energy Deployment System (ReEDS) is a long-term capacity-expansion model for the deployment of electric power generation technologies and transmission infrastructure throughout the contiguous United States (NREL 2018b).

ReEDS models future capacity installations on grids for the contiguous United States based on projections of electricity demand and the cost of developing new generation capacity within and among regions. ReEDS is an optimization routine, and it selects capacity additions among the available electricity generating technologies that minimize system costs within the model constraints and requirements. This requires the same degree of knowledge about the cost and availability of all the electricity generation technologies included in the model. ReEDS also needs supply curves for all these technologies. For *GeoVision*, the Annual Technology Baseline (ATB) was used (NREL 2018a). The ATB is a set of input assumptions updated annually by NREL to support and inform electric section analysis in the United States. Finally, ReEDS requires projections of electricity demand and fuel prices. These come from the Standard Scenarios, which are also updated annually by NREL. The *GeoVision* study assumes the NREL mid-case scenario for all modeling runes, unless otherwise noted. This scenario uses the middle, i.e., most likely, projections for technology costs, fuel costs, electricity demand, and other trends. *GeoVision* used the 2016 version of the ATB (Cole et al. 2016a) and the 2016 version of the Standard Scenarios (Cole et al. 2016b).

For more information about ReEDs, see: http://www.nrel.gov/analysis/reeds/

2.3 Barriers Expert Team (BET) Activities

For the institutional barriers analysis for GeoVision, 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.

The BET reviewed the following analysis activities in progression:

- Creation of the socio-economic attributes and sub-attributes to reflect the non-technical barriers faced by the geothermal industry.
- SEAT grading system, including for each sub-attribute a descriptive, objective qualifier for letters A to E, with E reflecting the most difficult barrier for the sub-attribute.
- Grading from A to E for each attribute that reflects the weighted sums of the sub-attributes to reflect the most difficult barrier for the attribute.
- Collection and/or creation of data to map each sub-attribute for the United States.
- Identification of 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 above, 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.*

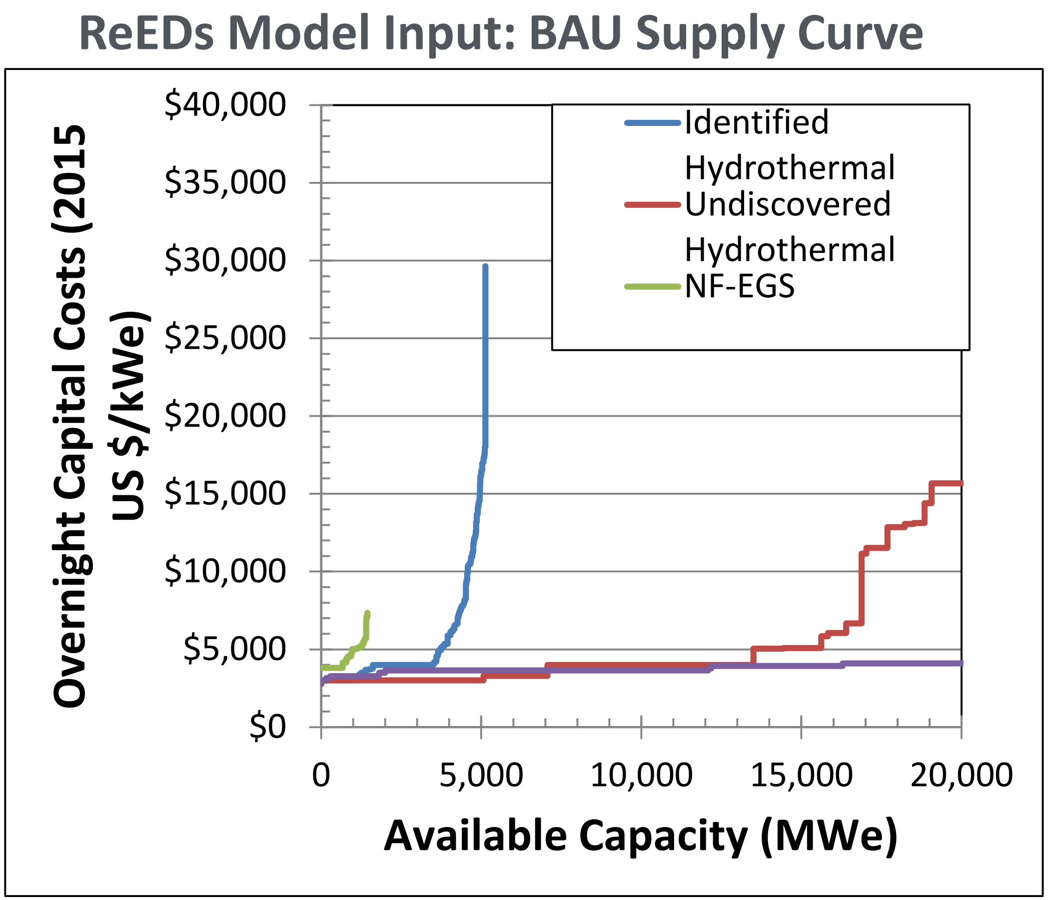
2.3 Barriers Expert Team (BET) Activities (continued)

- Identification of criteria for decision making on projects, including specific situations currently considered a ***significant barrier*** or that 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 to geothermal development.*
- Assignment of weights to each of the sub-attributes based on the sub-attributes' contributions 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).
- Combination of the sub-attribute maps into four attribute maps (land access, permitting, transmission, and market) using the BET-defined sub-attribute weights. The attribute maps reflect all of the areas where development was *unallowed* for the summed attribute grade. All maps are available on Geothermal Prospector (https://maps.nrel.gov/geothermal-prospector) and the Geothermal Data Repository (https://gdr.openei.org).
- Collection of costs for each grade of the sub-attribute to calculate the total costs for the four socio-economic attributes to determine whether specific socio-economic cost thresholds alone would make a geothermal project economically unfeasible.
- Assessment of the amount of geothermal resource potentially impacted by each attribute estimated by overlaying each of these attribute and sub-attribute maps over United States Geological Survey (USGS) maps of identified and undiscovered geothermal resource potential in the United States.

The combination of maps, cost data, and USGS resource potential were used to review and modify, if necessary, the inputs to GETEM runs conducted for the GeoVision Study's market penetration analysis.

3.1 Comparison Scenario: Business as Usual

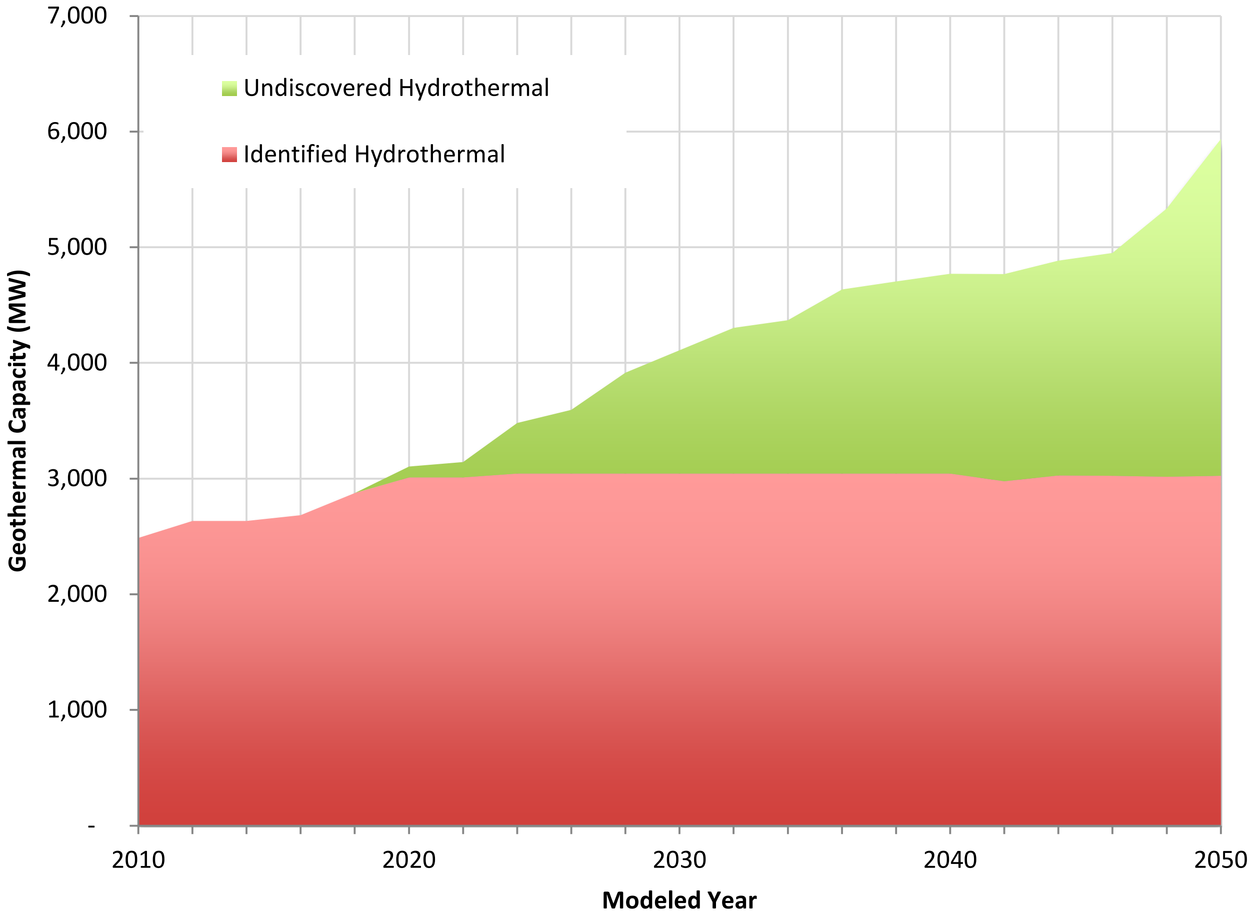
The first step in the GeoVision market penetration analysis is to establish the baseline: If business were to continue as usual (i.e., without improvements in cost or efficiencies)—a.k.a. business as usual or BAU case—what would the geothermal deployment in the United States look like between now and 2050?



The supply curve shown includes several types of geothermal resources, including identified hydrothermal, undiscovered hydrothermal, near-field enhanced geothermal systems (EGS), and deep EGS. The lowest-cost resources to deploy are hydrothermal and undiscovered, followed by a steep incline in cost (at about 30 GW) in developing EGS.

3.1 Comparison Scenario: Business as Usual

ReEDs Model Output: BAU Deployment Curve

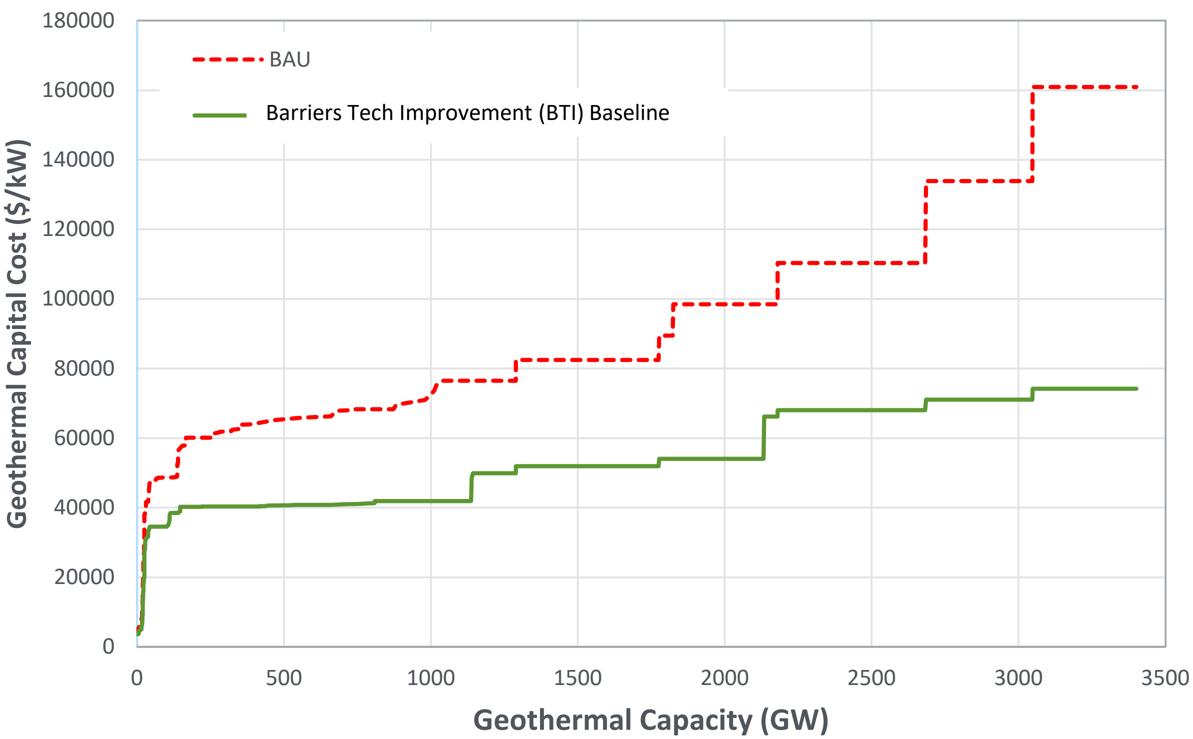


In the BAU scenario, we see identified hydrothermal resources being developed through 2020, then undiscovered resources developed through 2050, for a total deployment of 5.9 GWe. This corresponds to an increase in geothermal deployment of 3.5 GWe over the next 40 years.

3.2 Comparison Scenario: Disruptive Technologies

The next step in the GeoVision market penetration analysis is to develop a supply curve assuming potential disruptive technology improvements and then analyze the expected change in deployment if these improvements occurred—what would the new geothermal deployment in the United States look like between now and 2050?

ReEDs Model Inputs: Barriers Analysis Technology Improvement (BTI) Supply Curve

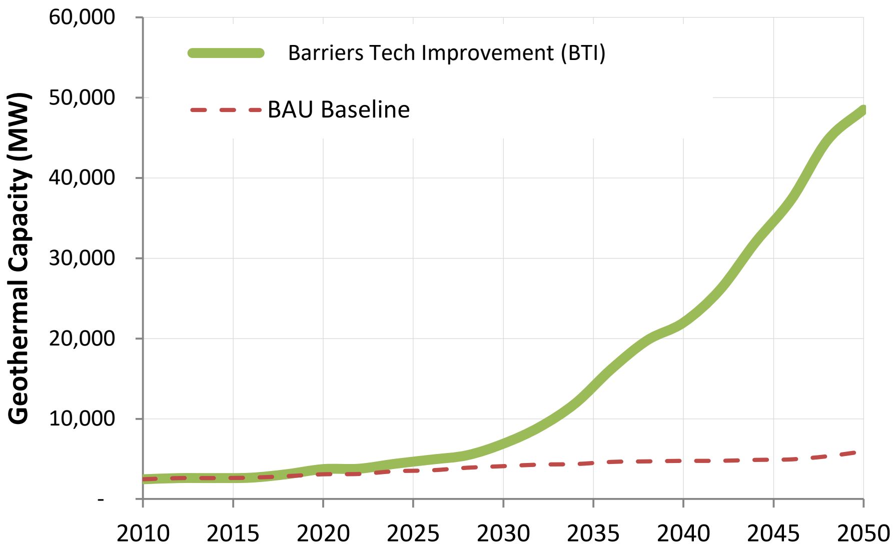


The improved technology case includes improvements in drilling costs, exploration success, and EGS technologies among other things (see P2P appendix for details) but does not include any improvements to non-technical barriers.

This BAU and BTI will be used as the comparison cases to measure potential improvements due to various barrier improvements.

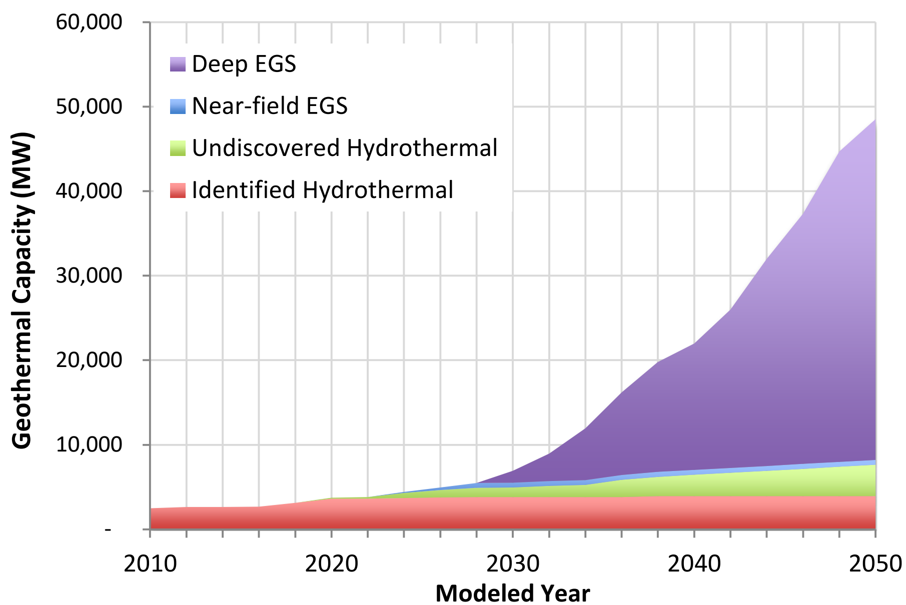
3.2 Comparison Scenario: Disruptive Technologies

ReEDS Model Output: Improved Technology Deployment Curve



The baseline BTI case deploys 48,515 MW of geothermal power. This is 42,480 MW over the BAU case (5,936 MW).

The baseline BTI case deploys:
3.9 GW of identified hydrothermal,
3.7 GW of undiscovered hydrothermal,
580 MW of near-field EGS, and
40.34 GW of deep EGS.



4.1.1 Barrier Overview: Land Access

- Understanding challenges to accessing land for geothermal development is important since environmental studies and private and public leases can take a considerable amount of time and delay or prevent project development.
- Recent studies (Young et al. 2014) showed that that the presence of certain resources and/or previous/existing land uses could cause projects to be delayed several years or more.
- We identified six sub-attributes that most significantly contributed to the ability to access land:
    - Cultural and Tribal Resources
    - Environmentally Sensitive Areas
    - Biological Resources
    - Land Ownership
    - Federal and State Lease Queue
    - Proximity to military Installation

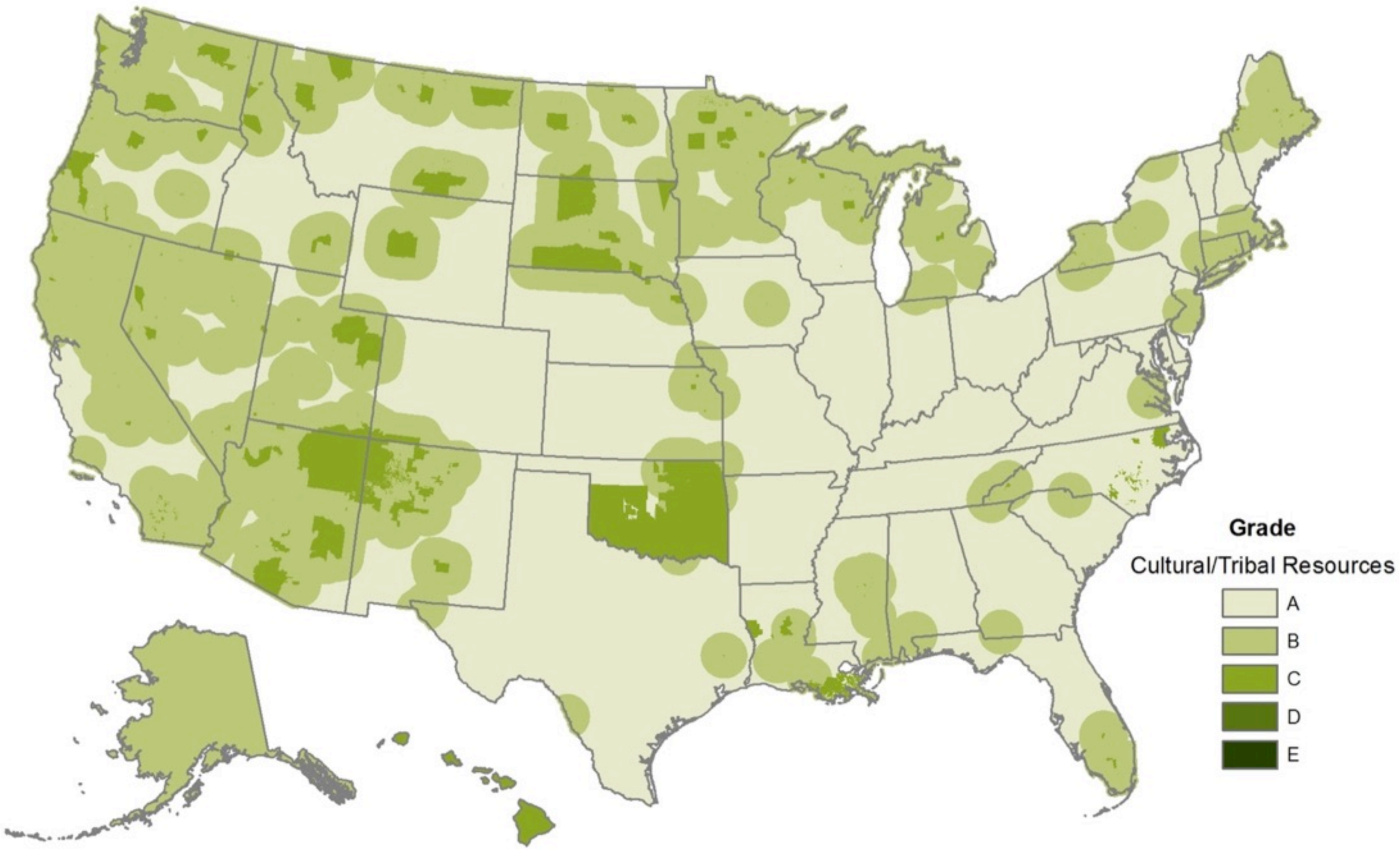
(For more information, see Levine and Young 2017a.)

Photo Credit: Kate Young

4.1.2 Land Access Sub-Attribute: Tribal and Cultural Resources

- Tribal concerns, particularly tribal involvement through significant public comment, are some of the most significant variables in the length of the NEPA process for geothermal development (Young et et al. 2014).
- The median environmental assessment (EA) with tribal concerns took 81 days longer to complete on average, while projects with significant tribal comments took 57 days longer to complete (Young et al. 2014).
- The cultural and tribal resources sub-attribute grade and map (next side) address whether a known cultural or tribal resource is present at the project location and the anticipated complexity of addressing or mitigating those resource concerns.
- Since cultural and tribal resources are difficult to map due to the lack of publicly available information, our map reflects grade estimates based upon known tribal areas.
- **Example**: *Glass Mountain Geothermal Resource Area* at Telephone Flat near Medicine Lake, California. The Medicine Lake Highlands are part of the Pit River Tribe's ancestral homeland. The project has encountered a series of delays based on multiple tribes, including Pit River, challenging that exploration and development interferes with tribal members' use of the area for a "variety of spiritual and traditional cultural purposes." [*See* Pit River Tribe v. BLM 793 F.3d 1147 (9th Cir. 2015)].

4.1.2 Land Access Sub-Attribute:
Tribal and Cultural Resources



A	No known cultural or tribal resources present. No State Historic Preservation Office (SHPO) concurrence required, 60-90 day review.
B	Manageable cultural/tribal resources. State-recognized jurisdictional tribal boundaries & 50-mile buffer for federally recognized jurisdictional tribal boundaries.~ 4 months for BLM and SHPO concurrence.
C	Cultural/tribal resource complications or federally recognized jurisdictional tribal boundaries. 6-9 months for BLM and SHPO concurrence.
D	Difficult cultural/tribal resource complications. +/- 1 year for BLM and SHPO concurrence.
E	Extreme cultural/tribal resource complications. 1-2 years for BLM and SHPO concurrence.

For the C grade, we mapped all federally recognized jurisdictional tribal boundaries.
Many developers said:

- Grade C would raise a *flag* in their assessments
- Grade D would be a *significant barrier* potentially preventing them from pursuing development
- Grade E area development is considered to be currently *unallowed*.

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

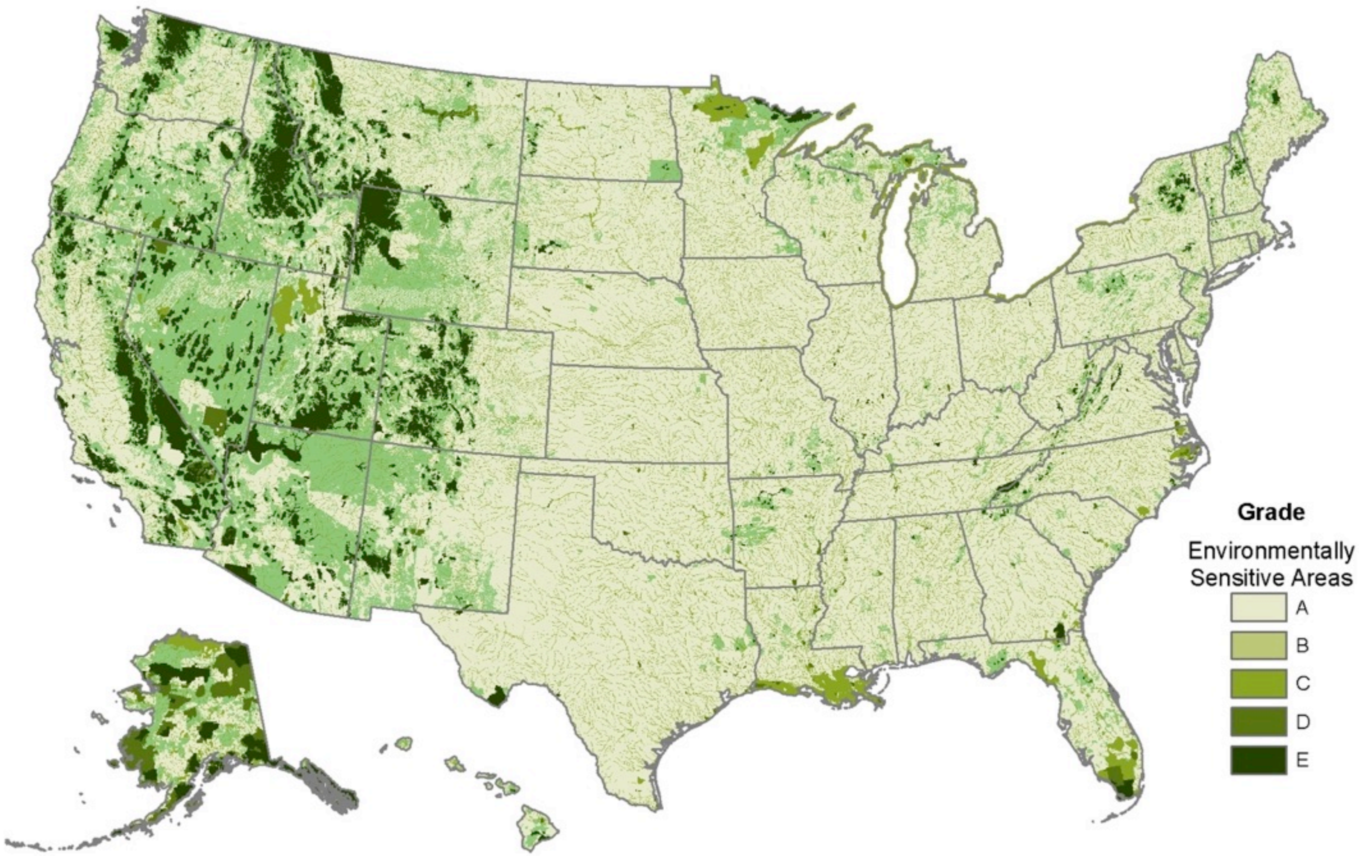
4.1.2 Land Access Sub-Attribute: Environmentally Sensitive Areas

The environmentally sensitive area (ESA) sub-attribute grades and map (next slide) address whether the project is located on or impacts an environmentally sensitive area such as Waters of the United States, national wildlife refuges, national parks, or other areas that may complicate or prevent development**. Examples include**:

- **Crump Geyser Geothermal Project** in Lake County, Oregon, included well sites determined to be in a wetland (i.e., Waters of the United States), which required extra permit approval (=extra time) from the State of Oregon and U.S. Army Corps of Engineers (Nevada Geothermal Power Inc. 2012).
- **Newberry Volcano Enhanced Geothermal System** (EGS) Demonstration Project is located next to the Newberry Volcano National Monument (NVNM), Oregon. Development within the NVNM was strictly prohibited, and stipulations included a 500-meter buffer between the created reservoir and rocks under the NVNM as well as a mitigation plan to protect the NVNM assets and visitors from the impacts of potential seismic events caused by the project (BLM, Record of Decision Newberry Volcano Enhanced Geothermal System Demonstration Project).

Wetlands in Lake County, Oregon

4.1.2 Land Access Sub-Attribute:
Environmentally Sensitive Areas



A	Not located in an environmentally sensitive area. 2-3 month staff review.
B	Manageable environmental sensitivities (recreational, geologic, wildlife ,or scenic value). 3-6 month staff review.
C	Environmentally sensitive area complications (e.g., Waters of the United States). 6-12 month staff resolution.
D	Difficult environmentally sensitive area complications (e.g., wild and scenic rivers, wildlife refuge, national preserves). Not likely to resolve; 1-2 years or longer if resolution possible.
E	Extreme environmentally sensitive area complications (e.g., national park, national monument, wilderness areas or wilderness study areas, private conservation land). Not likely to be resolved; 2+ years

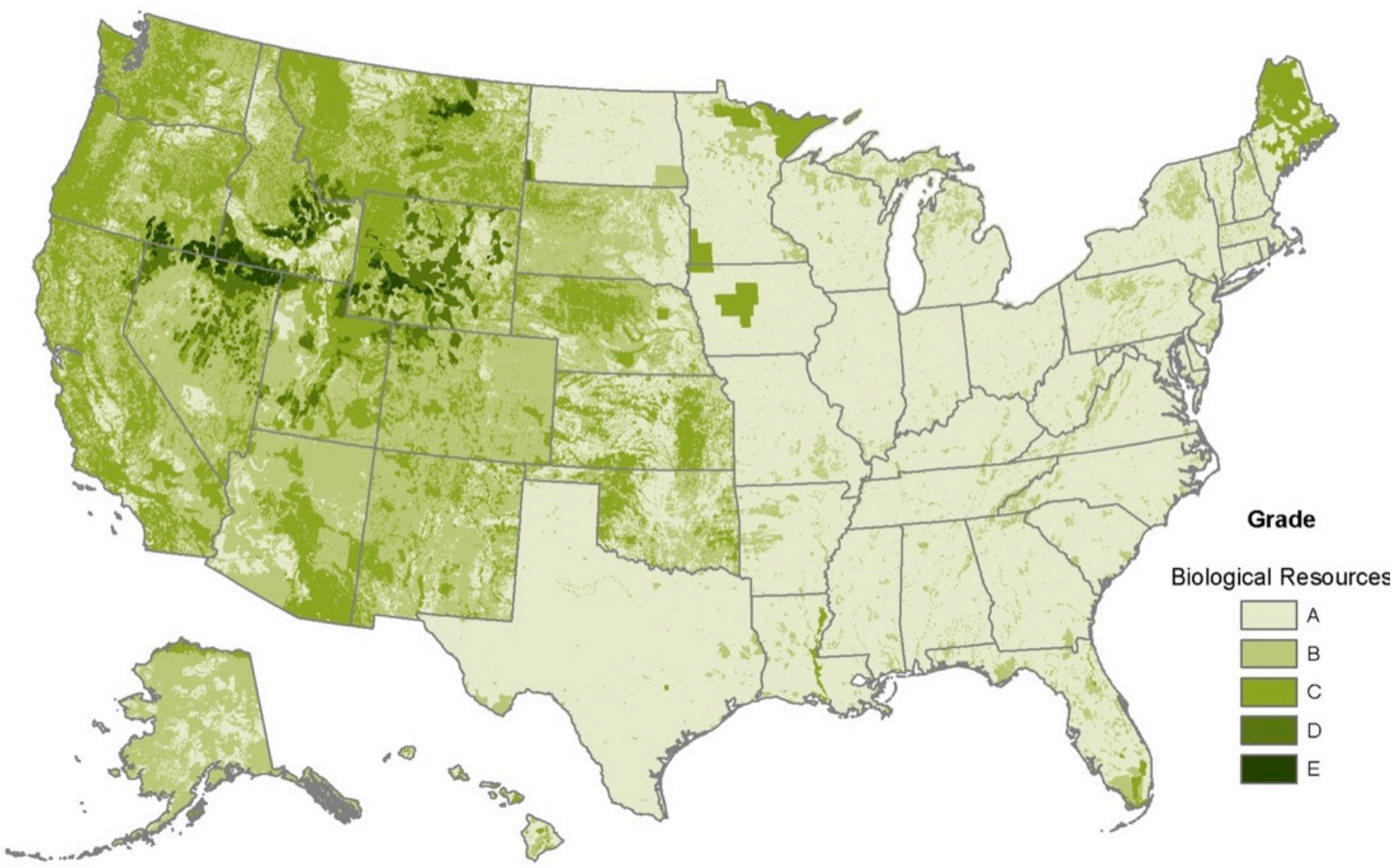
All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.1.2 Land Access Sub-Attribute: Biological Resources

- The biological resources sub-attribute grades and map (next slide) address whether the project may impact species or their habitat, including species of concern, threatened and endangered species, protected avian species, and sage grouse habitat.
- NEPA timeframes: The presence of federally endangered species and migratory birds were recorded as two of the most significant variables in the length of the NEPA process. The median EA with federally endangered species present took 69 days longer to complete, while the median EA with migratory birds present took 177 days longer to complete (Young et al. 2014).
- **Sage grouse:** Current sage grouse rules have created challenges for geothermal developers. The Bureau of Land Management (BLM) and Forest Service finalized new land-use plans in 2015 to conserve habitat and identify threats to sage grouse and sagebrush. In part, the new land-use plans eliminate most new surface disturbance in sage grouse Priority Habitat Management Area (PHMA) focal areas, avoid or limit new surface disturbance in PHMAs, and minimize surface disturbance in General Habitat Management Areas (GHMAs) (BLM 2015).
- **Example**: *Waunita Hot Springs*, a geothermal resource near Gunnison, Colorado, is home to the Gunnison sage grouse, and the entire lease area is within the sage grouse habitat. This led to the creation of BLM geothermal lease stipulations that have deterred investment in the project site.

Greater Sage Grouse

4.1.2 Land Access Sub-Attribute: Biological Resources



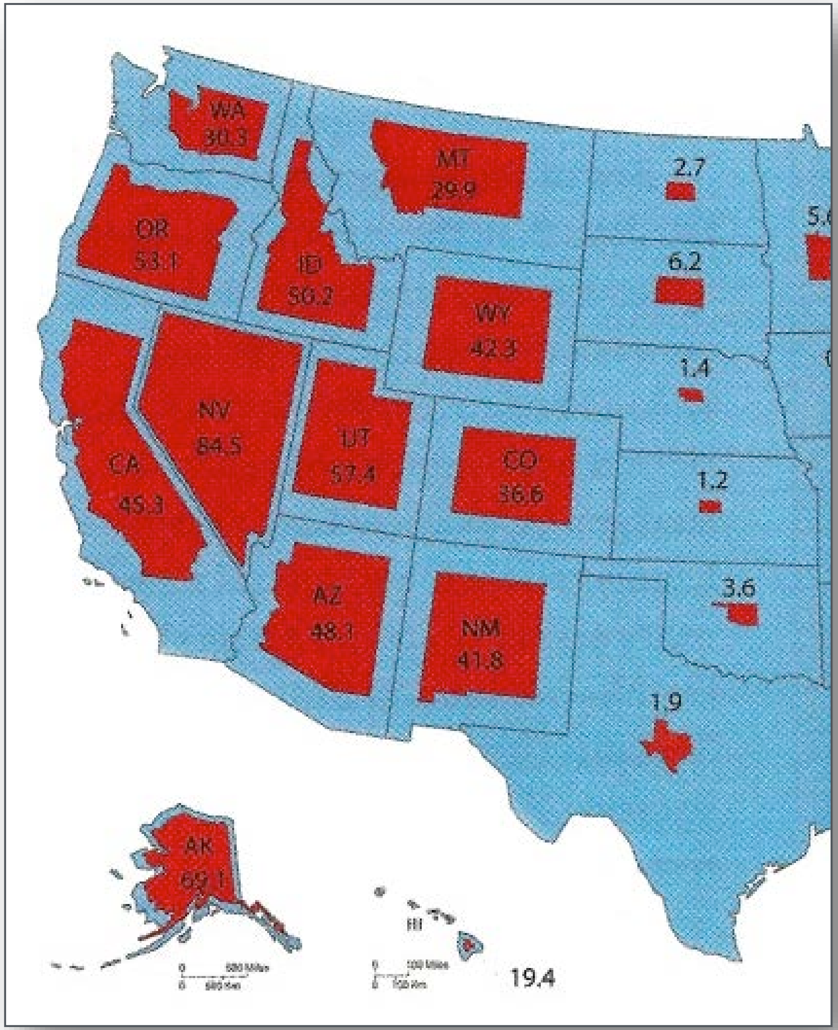
A	No biological resource issues. 60-90 day staff review.
B	Manageable biological resource issues (e.g., nearby species of concern) 3-6 month staff review.
C	Biological resource complications (e.g., endangered or threatened species nearby, migratory birds, bald/golden eagles). Sage grouse GHMA 6-12 month staff resolution.
D	Difficult biological resource issues (e.g., nearby or present endangered species). Sage grouse PHMA. Not likely to resolve; 1-2 years or longer if resolution possible.
E	Sage grouse PHMA focal areas.

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.1.2 Land Access Sub-Attribute: Land Ownership

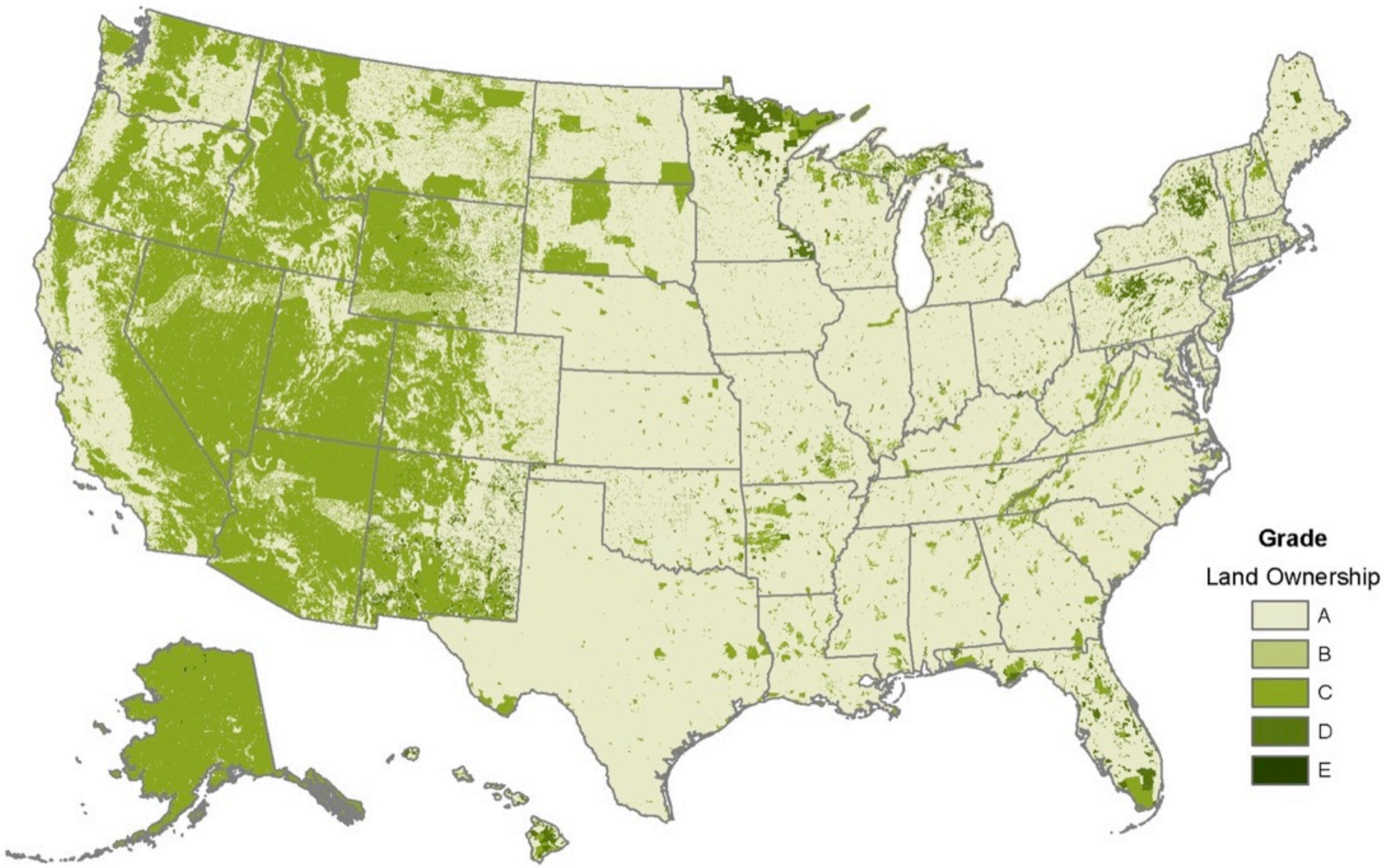
- The land ownership sub-attribute grades and map (next slide) address whether the project is located on federal, state, or private land. The ownership of land sought for geothermal development may impact project costs or development time.
- Projects with multiple landowners, particularly in the form of distinct surface owners and sub-surface owners (i.e., split estate) or multiple federal agencies may increase project complexity.
- **For example,** the average time for the 11 projects with Forest Service *and* BLM jurisdiction took 60 days longer to complete than the 28 projects completed solely by the BLM (Young et al. 2014).

Federal Land as a Percentage of Total State Land Area



Data Source: U.S. General Services Administration, Federal Real Property Profile 2004, excludes trust properties

4.1.2 Land Access Sub-Attribute: Land Ownership



A	Private land, single owner
B	Private land, multiple owners (with potential split estate issues)
C	Federal or state land with well-defined geothermal leasing regulations
D	State land without defined geothermal leasing regulations
E	Multiple landowners (federal, state, or private combination with potential split estate issues)

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

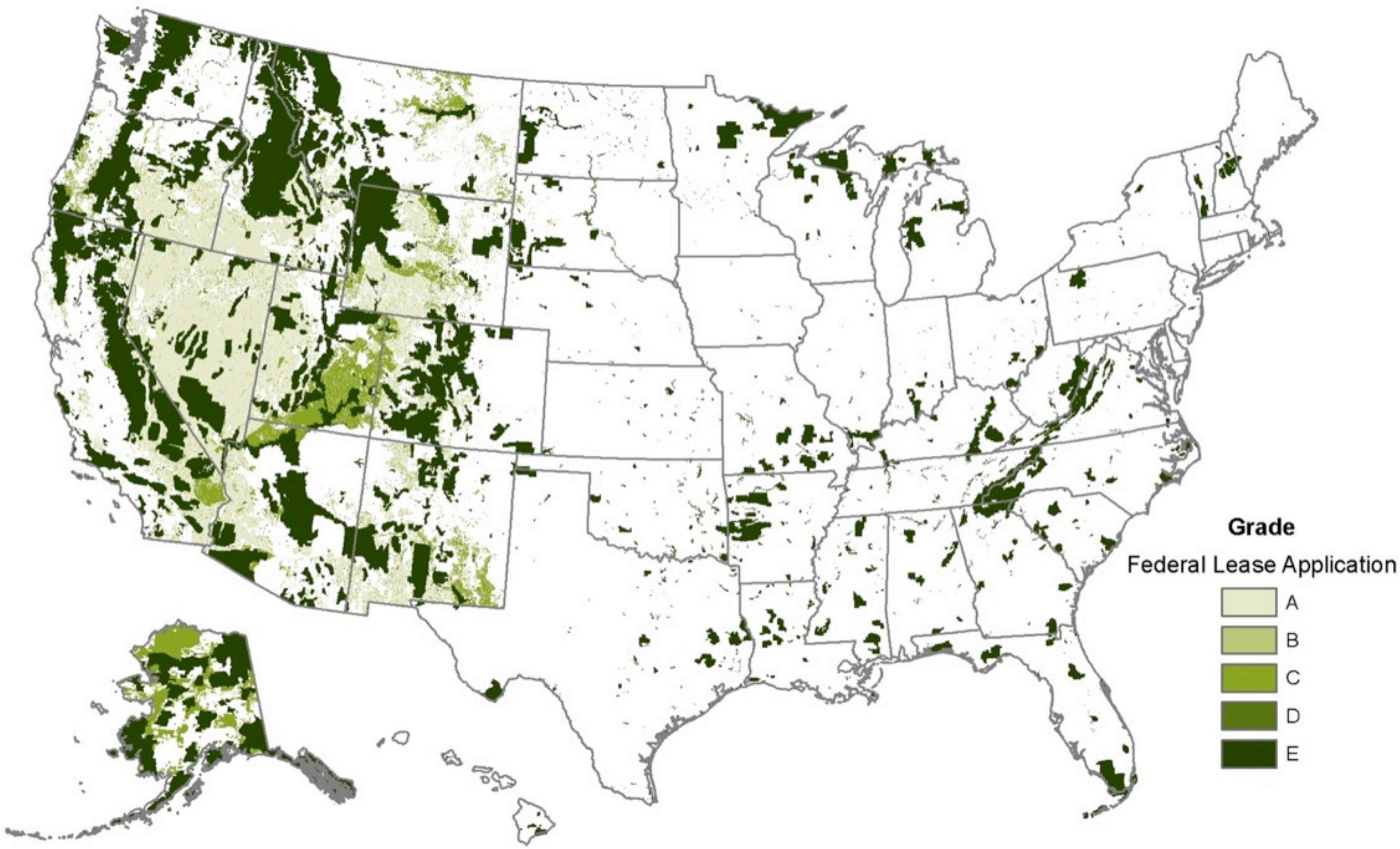
4.1.2 Land Access Sub-Attribute: Lease Queue

Federal Lease Queue

- The federal lease queue sub-attribute grades and map (next slide) address the anticipated time a project proponent may have to wait on the BLM or the Forest Service to complete the applicable pre-leasing analysis and post the parcel for lease sale after nomination.
- Federal lands nominated for geothermal leases must go through an environmental review process by the federal land management agency(s).

- Section 225 of the Energy Policy Act of 2005 (EPAct) required a program for reducing the backlog of geothermal lease applications on National Forest System lands by 90% within 5 years of enactment. In furtherance of this requirement, in October 2008, the U.S. Department of Interior (DOI) (who oversees the BLM) and the U.S. Department of Agriculture (who oversees the Forest Service) finalized a Programmatic Environmental Impact Statement (PEIS) for Geothermal Leasing in the Western United States (BLM and Forest Service 2008).
- EPAct temporarily increased funding for geothermal lease processing, helping to address the backlog. However, with the end of this funding, the agencies returned to pre-EPAct funding levels (Witherbee et al. 2013).
- **Example**: In the past, low levels of geothermal funding and/or available staff—particularly at the Forest Service —created backlogs of geothermal project leases awaiting processing, with some applications sitting in the queue for 34 years (BLM and Forest Service 2008).

4.1.2 Land Access Sub-Attribute:
Lease Queue - Federal



	Queue for Federal Lease Application:
A	<1 year
B	<2 years
C	<3 years
D	<5 years
E	>5 years

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

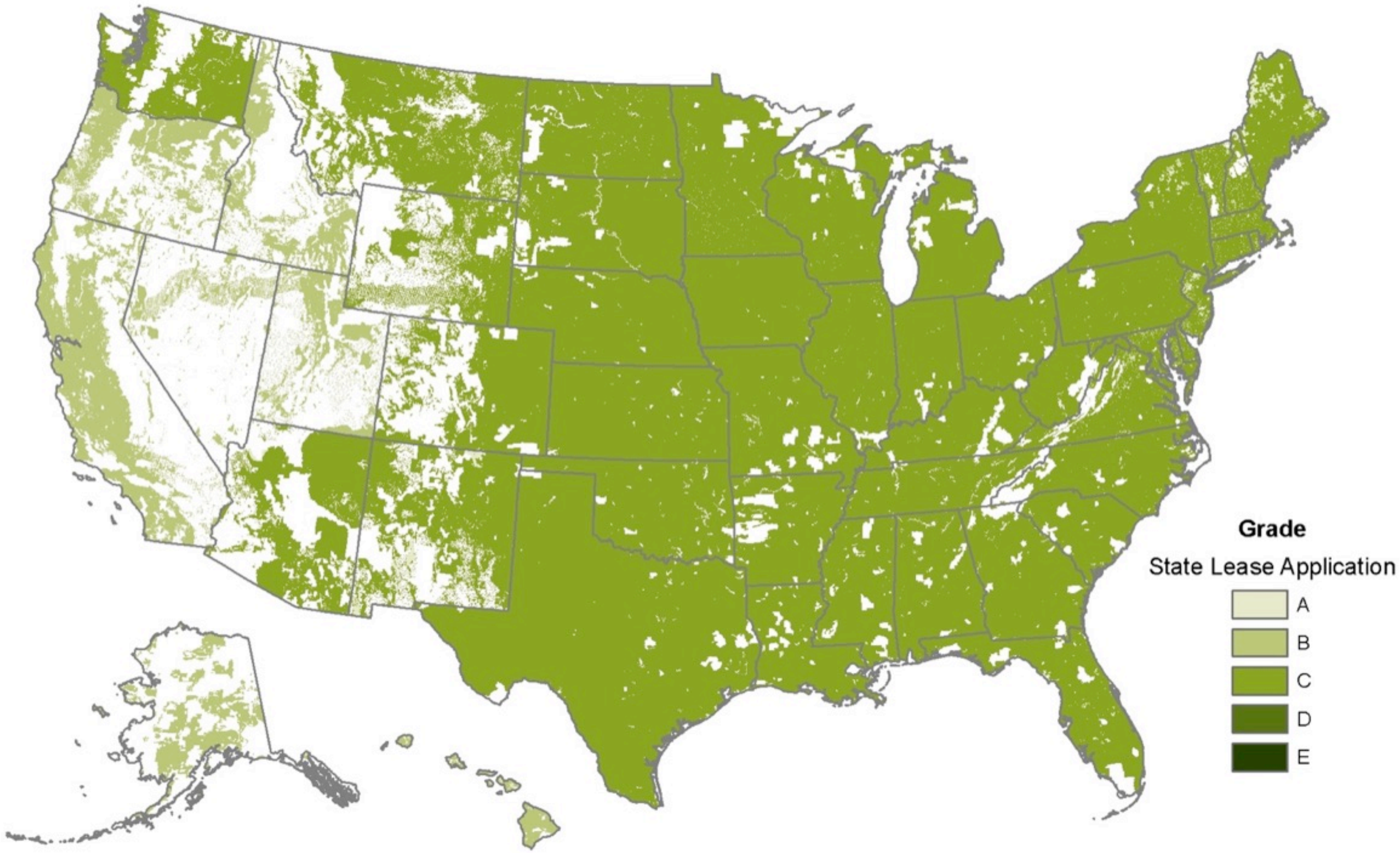
4.1.2 Land Access Sub-Attribute: Lease Queue

State Lease Queue

- The state lease queue sub-attribute grades and map (in 2 slides) address the anticipated time a project proponent may have to wait for a state land board to complete any applicable pre-leasing analysis and post the parcel for lease sale. This attribute applies only to non-federal lands and complements the Federal Lease Queue map.
- State leasing may be an issue if the state does not have experience in leasing state land for geothermal development or does not have a specific regulation in place for leasing state land for geothermal development.

Photo credit: Dennis Schroeder

4.1.2 Land Access Sub-Attribute:
Lease Queue - State



	Queue for State Lease Application:
A	<1 year
B	<2 years
C	<3 years
D	<5 years
E	>5 years

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.1.2 Land Access Sub-Attribute: Proximity to Military Installation

- All military installations have a demand for power and a desire to be energy independent. Under 10 USC § 2911(g)(1) the DoD has established a broad goal of meeting 25% of DoD's energy needs with renewable energy by 2025 and each year thereafter.

Photo Credit: Kate Young *Coso Geothermal Area, CA*

Two barriers typically are encountered on every DoD installation:

- **Military Barrier 1:** Development may have potential impacts on the mission.
- **Military Barrier 2:** Understanding authority for geothermal resource development on military land.

4.1.2 Land Access Sub-Attribute: Proximity to Military Installation

Military Barrier 1: Development may have potential impacts on the mission.

- Chief concerns among all installation commanding officers (ICOs) are meeting mission requirements and preventing encroachment.
- By definition, the use of military land for anything other than mission-related activities (e.g., developing utility-grade or direct-use geothermal resources) is potentially in conflict with an installation's mission.

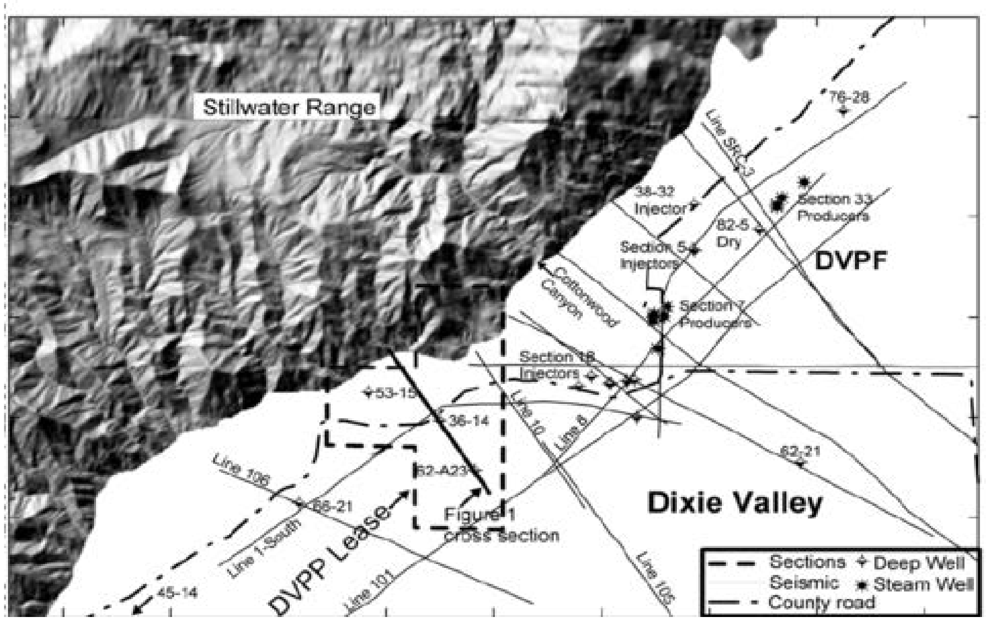
Example: Personnel at the Coso geothermal field, Naval Air Weapons Station (NAWS) China Lake, California, are evacuated from the field up to 20-30 times per year in order to facilitate NAWS range tests. If Coso were not evacuated, these range tests might be limited and Coso might be seen as encroaching on mission activities. Proposed exploration and development activities on or near base boundaries may also be perceived as encroaching on mission activities.

Photo Credit: Kate Young *Coso Geothermal Field, China Lake, California*

4.1.2 Land Access Sub-Attribute: Proximity to Military Installation

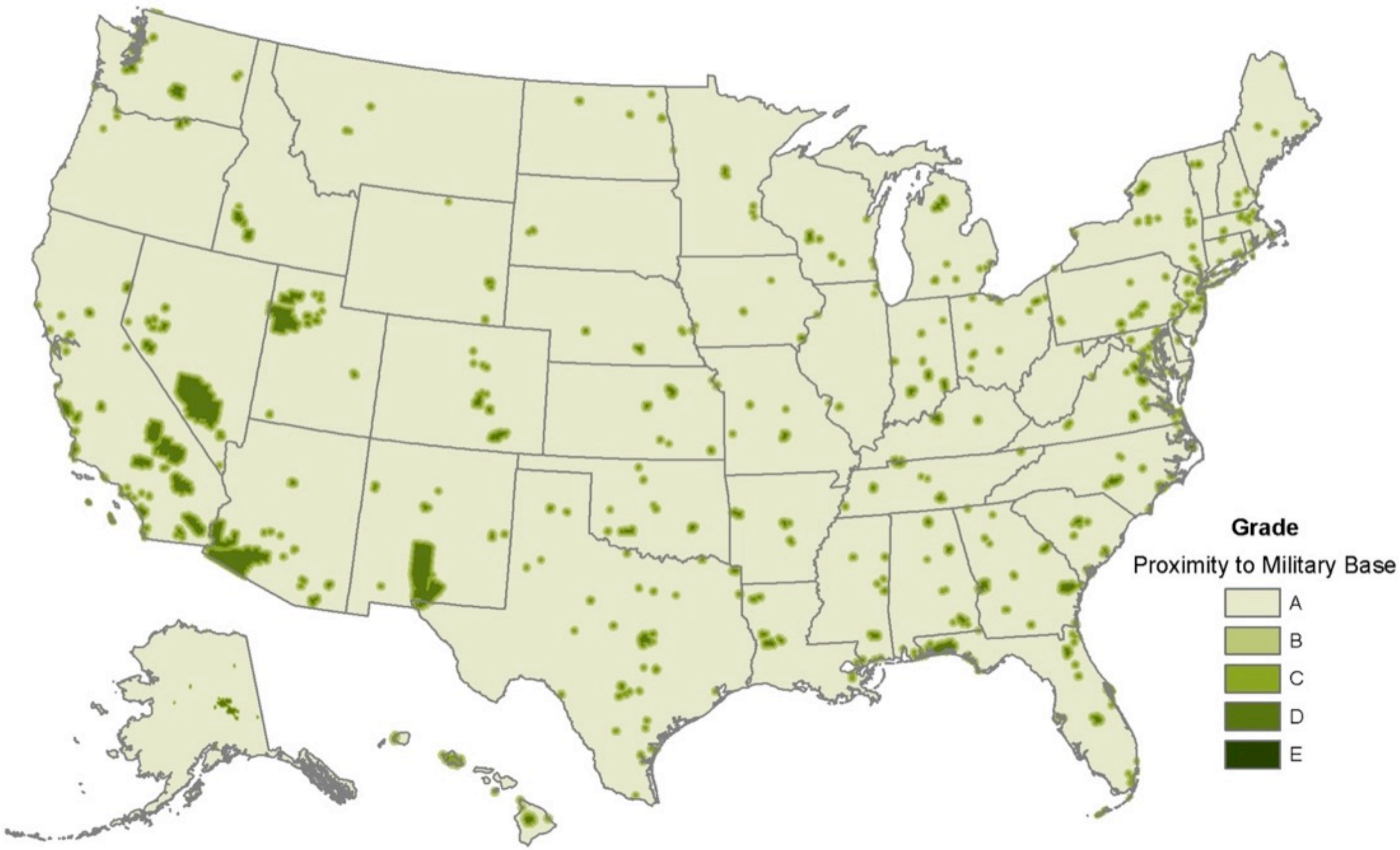
Military Barrier 2: Understanding authority for geothermal resource development on military land.

- Much of the land that constitutes military bases in the western United States was withdrawn from public use from the DOI by DoD for military purposes.
- All federal mineral rights—other than these DoD withdrawn lands—are managed by the BLM. The military manages all lands inside their installation fence lines.
- At the same time, the Navy Geothermal Program Office (GPO) invokes the authority to explore, develop, and sell geothermal resources on military installations, as defined in 10 USC 2916 and 2917.
- The apparent contradictory language embedded in 10 USC 2916 and 2917 versus specific withdrawal language, among other issues, was to be resolved by the Interagency Military Land Use Coordinating Committee (IMLUCC). The IMLUCC was convened to address this issue; however, no resolution was generated.



Example: The impasse over who has the authority to develop potential geothermal resources inside DoD-managed land still exists, and potentially developable resources described by the GPO in Dixie Valley and at Hawthorne Army Depot remain undeveloped (Alm et al. 2016; Meade et al. 2011).

4.1.2 Land Access Sub-Attribute: Proximity to Military Installation



A	Not located near military installations
B	Located within 10 miles of military installations
C	Located within 5 miles of military installations
D	Located on a military installation
E	Negatively impacting a military installation

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.1.3 Land Access: Influence on Potential

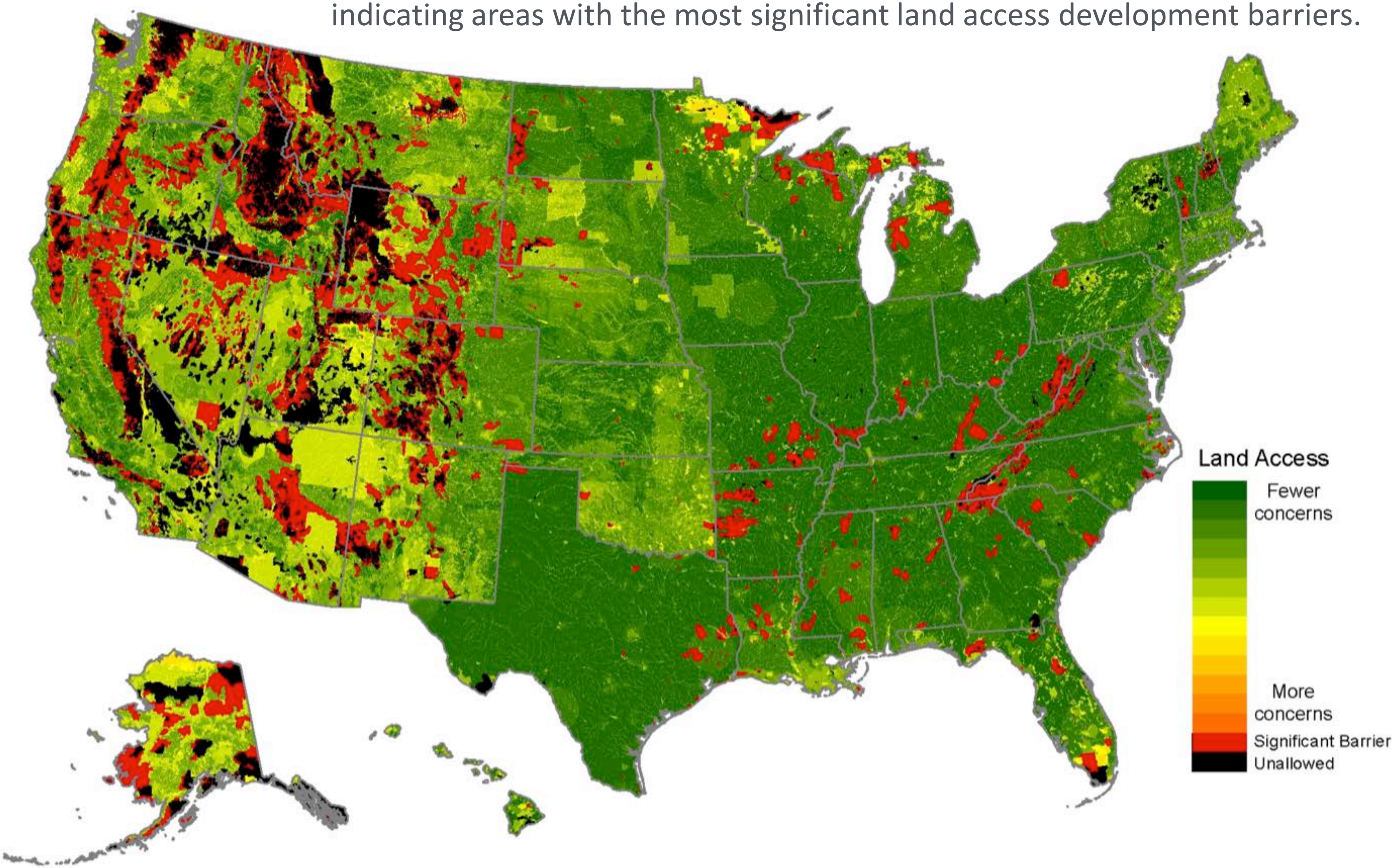
- This table provides a summary of flagged, significant barrier, and unallowed grades for each of the land access sub-attributes.
- Three of the six sub-attributes identify lands that are legally unallowed for geothermal development and prevent development of some of the resources identified by the USGS in their 2008 resource assessment.
- All of the sub-attributes show significant barriers and/or flagged grades, indicating land access as one of the most significant barriers to geothermal development.

1. Sub-Attributes Analyzed	Unallowed Grade(s)	Significant Barrier Grade(s)	Flagged Grade(s)
Tribal and Cultural Resources	*E*	*D*	**C**
Environmentally Sensitive Areas	**E**	**D**	**C**
Biological Resources	**E**	**D**	**C**
Federal Lease Queue	--	**E**	**C**
State Lease Queue	--	*E*	**C**, *D*
Land Ownership	--	--	*D, E*
Military Installation	--	*E*	**C, D**

Note: **Bolded** grades indicate data were available for mapping this sub-attribute. *Italicized* grades indicate that no data were available for mapping.

4.1.3 Land Access: Influence on Potential

This map summarizes all six land access sub-attributes into a single map, indicating areas with the most significant land access development barriers.



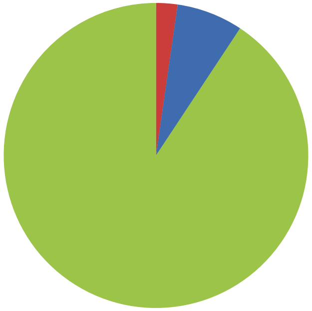
All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.1.3 Land Access: Influence on Potential

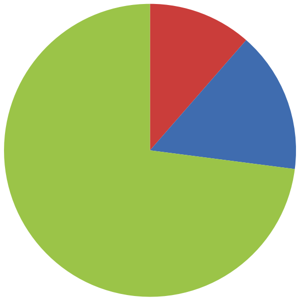
Units: Capacity available for deployment (MW)

	OVERVIEW	Identified	Undiscovered	NF EGS	EGS	Description
P2P	Total Resource	9,197	30,033	--	--	As reported by the USGS and by GVS P2P Taskforce for EGS.
P2P	**Max Available**	**5,669**	**25,807**	**1,493**	**5,124,890**	Removes installed capacity; no removal for temperature.
Barriers	Unallowed	129	2,953	--	619,419	Unallowed areas were removed due to federal mandates that prevent development.
Barriers	Significant Barriers	399	4,025	111	1,152,851	Significant barriers include resource concerns that could potentially be mitigated.
Barriers	Available Now for Deployment	5,140	18,830	1,382	3,352,620	This is the max available (as determined by the P2P team) less the unallowed and significant barriers.
Barriers	Best Case	5,540	22,854	1,493	4,505,471	All significant barriers have the potential to be mitigated; unallowed areas are assumed not to be developable.

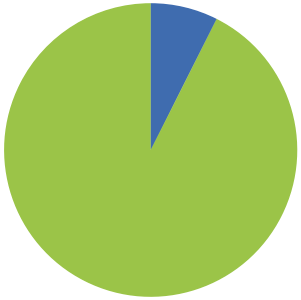
Identified MW



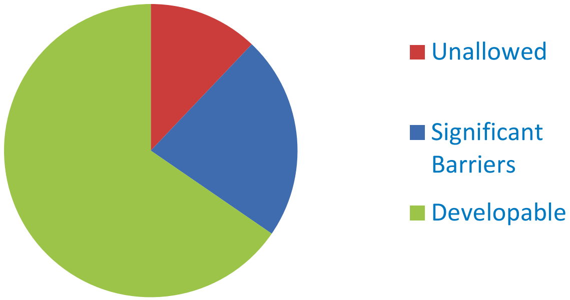
Undiscovered MW



Near-Field EGS MW



EGS MW



4.1.4 Land Access: Improvement Scenarios

Scenarios	Description – Bottoms-Up Story	Model Inputs	
		Resource Type	Available MW
BAU	• Land access becomes more restrictive as more land becomes unavailable due to biological restrictions (e.g., sage grouse plans, pup fish threatening to close southern half of Nevada). • 2030 and 2050 estimates for identified and undiscovered resources remove deployed resources and include an additional 10% reduction in 2030 and 2050 due to growing land restrictions. • EGS is assumed to be zero for BAU.	Identified	4,027
		Undiscovered	13,073
		NF EGS	1,382
		EGS	3,352,620
SCENARIO 1: Low Improvement Case	• **Forest Service prioritizes funding/staff availability** to process geothermal leases (similar to EPAct 2005)—all capacity on Forest Service gets added back into supply curve	Identified	+49
		Undiscovered	+2,517
		NF EGS	+61
		EGS	+478,733
SCENARIO 2: Disruptive Improvement	**Low case, PLUS:** • **Design of mitigation measures** that will allow development with minimal surface impact (e.g., oil and gas lays down rubber mats that protect the top soil and root system), allowing access to additional (but not all) areas with biological concerns and environmentally sensitive areas.	Identified	+49 +350
		Undiscovered	+2,517 +1,508
		NF EGS	+61 +50
		EGS	+478,733 +674,118

4.1.4 Land Access Improvement Scenario: Low Improvement: Forest Service Funding

Forest Service Prioritizes Funding/Staff Availability to Process Geothermal Leases and Permits

- While the BLM receives a specific budget for processing geothermal lease applications and permits, the Forest Service does not have a geothermal-specific budget, and instead, geothermal activities requiring Forest Service approval are funded as part of the minerals and geology line item, which accounts for less than 1% of the Forest Service annual budget (Witherbee et al. 2013).
- Lack of funding priority and/or staff availability for processing leases and permits, particularly at the Forest Service, created backlogs of geothermal project leases (i.e., a federal lease queue) awaiting processing.
- Some applications had been sitting in the queue for 34 years (BLM and Forest Service 2008).
- In response, as part of EPAct 2005, Congress established a program for leasing of lands in the National Forest System (i.e., lands managed by the Forest Service) and to reduce the backlog of geothermal lease applications pending on January 1, 2005, by 90% within 5 years of enacting the statute [EPAct § 225(b)(3)].
- With the end of the Congressionally authorized mandate and funding to clear the lease queue, the Forest Service returned to its pre-EPAct funding/staffing scenario (Witherbee et al. 2013).
- As a result, we classified un-leased National Forest System lands as a developer-identified significant barrier in Chapter 2.

Attribute: Land Access
Low Improvement Scenario: Forest Service Funding/Staff Prioritization

This improvement scenario analyzes the impacts of continuous geothermal funding prioritization and staff availability for the Forest Service to process lease applications and permits on National Forest System lands.

4.1.4 Land Access Improvement Scenario: Disruptive Improvement: Mitigation Design

Environmental Mitigation Measures

- Most of the geothermal resource potential identified by the 2008 USGS assessment is not legally “unallowed” for development (e.g., national parks, national monuments).
- In addition, a large portion was identified during this analysis as having a significant barrier that potentially prevents development.
- These barriers fell into three main categories: cultural and tribal resource areas, environmentally sensitive areas, and biological resource areas.
- Sites may include Wild and Scenic Rivers, National Wildlife Refuge, National Preserves, and Sage Grouse PHMAs.
- The design of mitigation measures that allow development with minimal surface impact could move these areas out of the significant barrier classification.

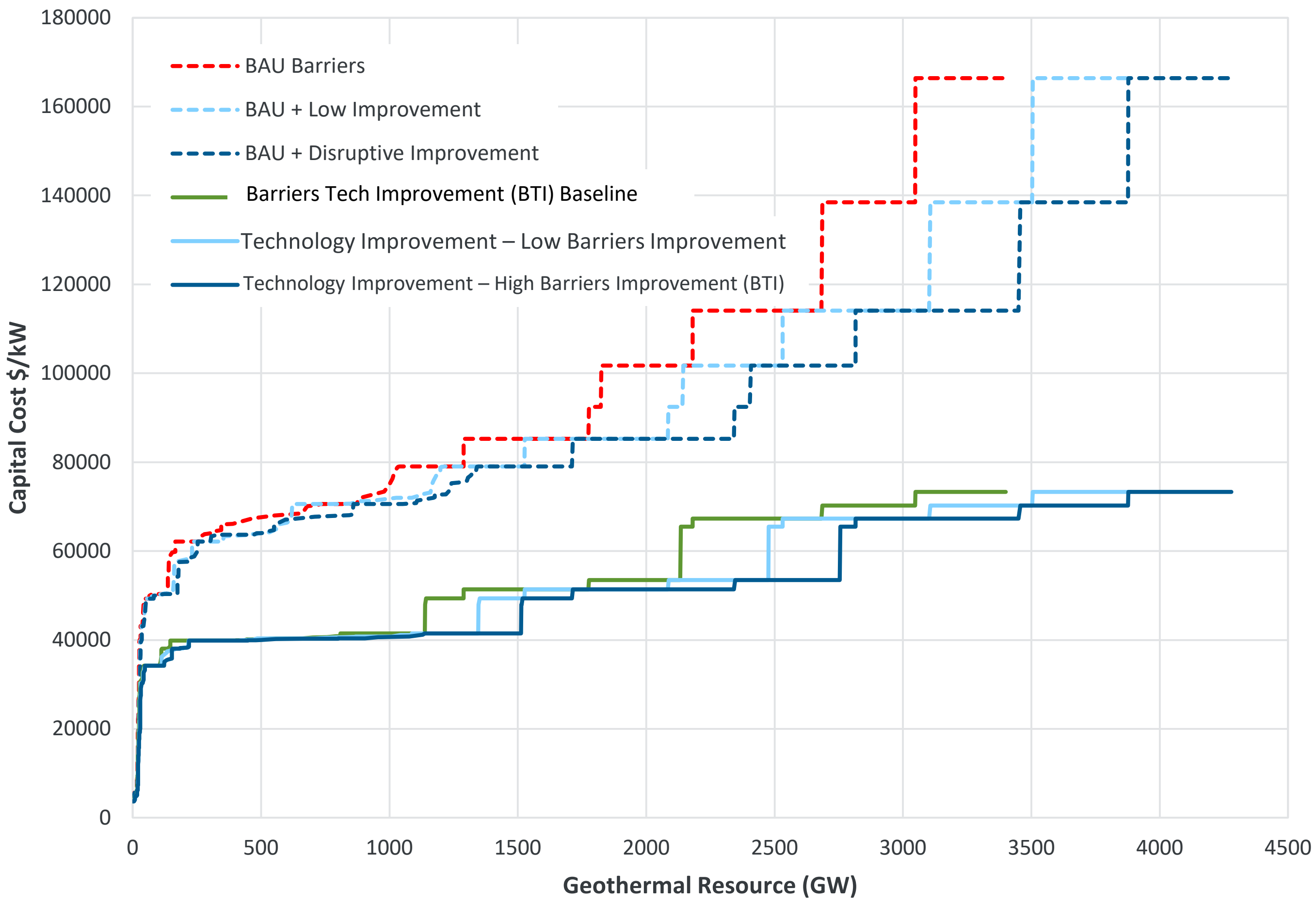
- Example mitigation measures include:
  - Using portable pits rather than digging pits
  - Laying pallets down to make temporary roads so as not to disturb sagebrush roots.

Attribute: Land Access
Disruptive Improvement Scenario: Mitigation Design

This disruptive improvement scenario combines the low improvement scenario (Forest Service prioritizing funding/staff to process geothermal permits and leases) with the design of mitigation measures that allow access to additional (but not all) significant barrier areas.

4.1.5 Land Access: Model Inputs

Land Access impacts to the BTI Case



2. Model Input Affected
Supply
Cost
Timeline
Demand
Technology Selection
Transmission

The land access improvements have the same impact on the high-tech case: increasing the amount of available supply.

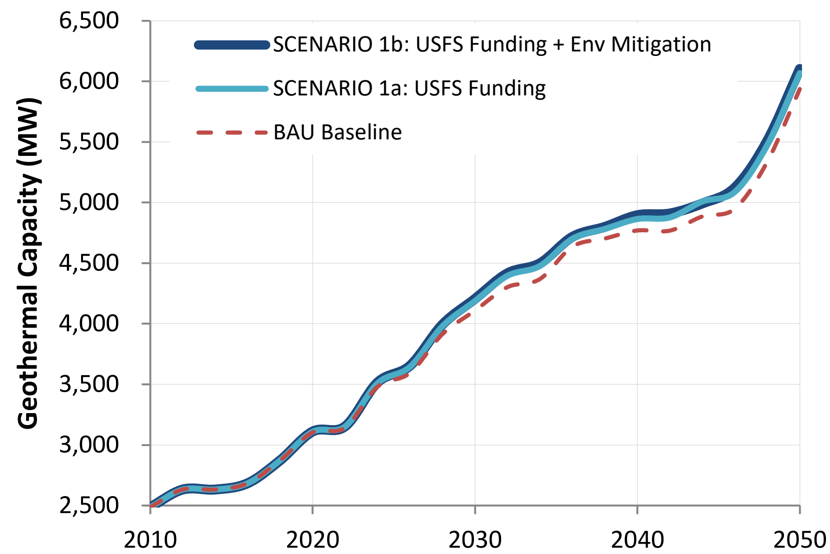
In the **low improvement** cases, National Forest System lands are made accessible through Forest Service prioritization of funding and staff availability.

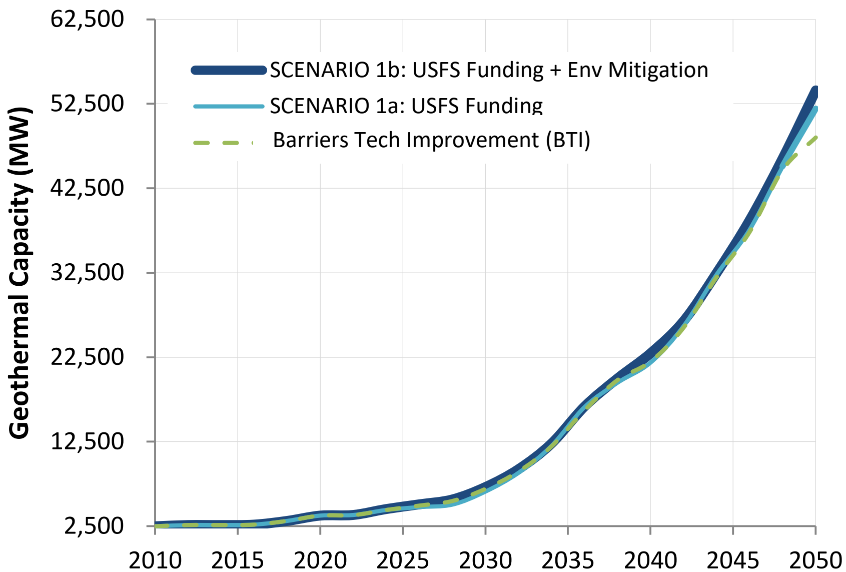
Disruptive/high improvements include both Forest Service prioritization and mitigation measures.

4.1.5 Land Access: Model Results

Improvement	over BAU	over BTI
1a: Forest Service	130 MW (2%)	4.0 GW (8%)
1b: Forest Service + Env Mitigation	170 MW (3%)	5.6 GW (12%)

- Though land access improvement scenarios make more land available, it does not lower cost.
- Therefore, alone, these improvements have only minimal impact on deployment in both the BAU and BTI cases.
- In addition to land availability, land access barriers also have the potential to impact project timelines. Due to modeling limitations, project timeline impacts were not modeled for land access improvement scenarios. Timeline improvements were modeled in other scenarios that suggest that timeline improvements (and therefore land access improvements) have the potential to have significant impact on geothermal deployment.





4.2.1 Barrier Overview: Permitting

- 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, state, 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).
- We identified three sub-attributes that most significantly contributed to the ability to permit:
    - Regulatory framework
        - State
        - Federal
    - Environmental review process
    - Ancillary permits

(For more information See Levine and Young 2017b.)

Photo Credit: Kate Young

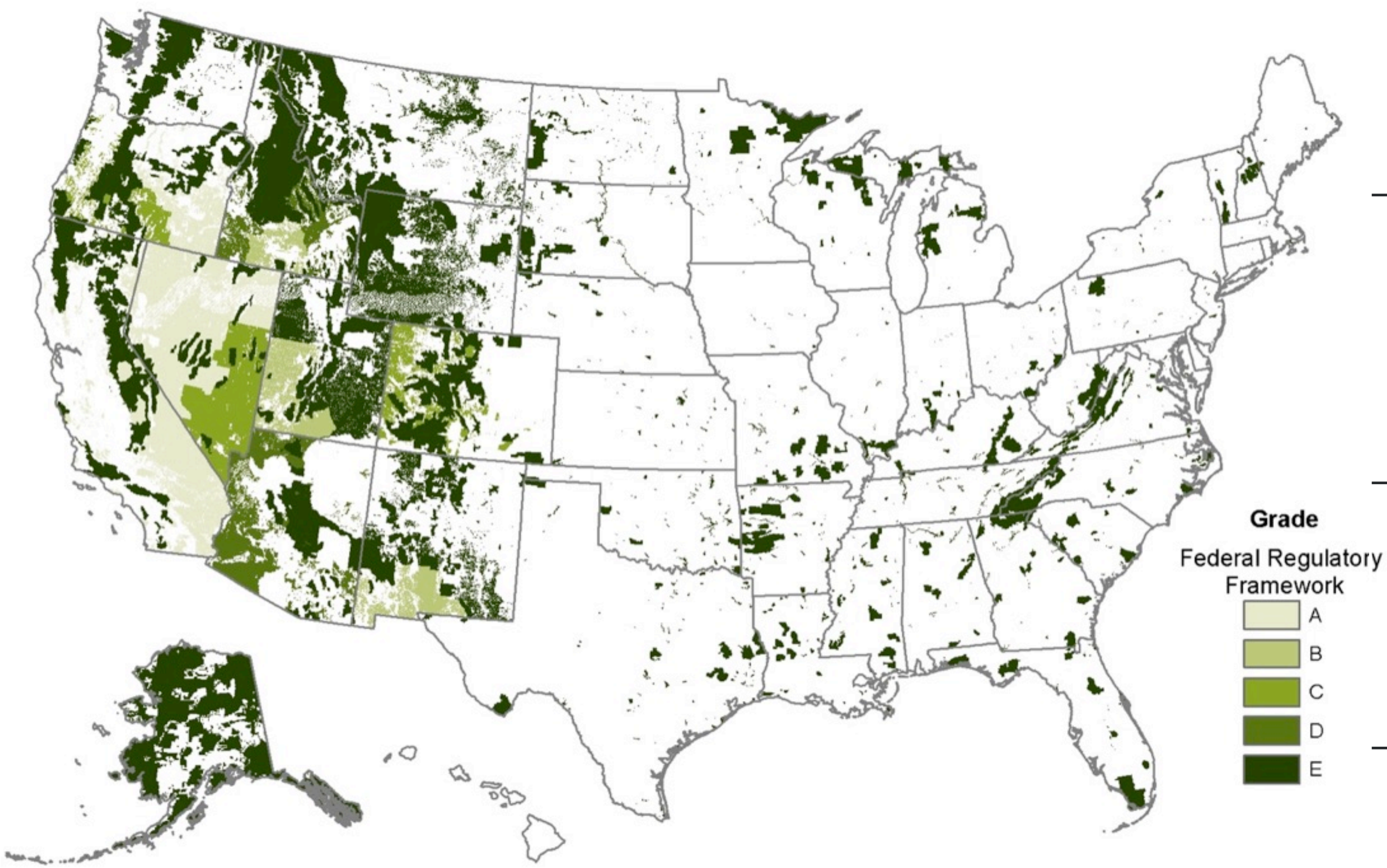
4.2.2 Permitting Sub-Attribute: Regulatory Framework: Federal

- A lack of experienced regulatory personnel and lack of interagency coordination were two situations cited by industry and agency personnel to delay geothermal project development (Young et al. 2014).
- The federal regulatory framework sub-attribute grades and map (next slide) address:
  - The knowledge of the permitting experts and knowledge within regional offices (e.g., BLM district office or individual national forest) specific to geothermal development
  - Whether the regional office has a memorandum of understanding (MOU) with the applicable state.

Example: The BLM Nevada office, particularly the district offices in Battle Mountain, Carson City, and Winnemucca, have considerable experience permitting geothermal projects. In addition, BLM Nevada and the Nevada Division of Minerals have entered into an MOU defining roles and responsibilities of each agency for geothermal permitting, operations, and inspections in Nevada (BLM 2006).

Blue Mountain Geothermal Power Plant, Humbolt County, NV
Photo credit: Dennis Schroeder

4.2.2 Permitting Sub-Attribute:
Regulatory Framework: Federal



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

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

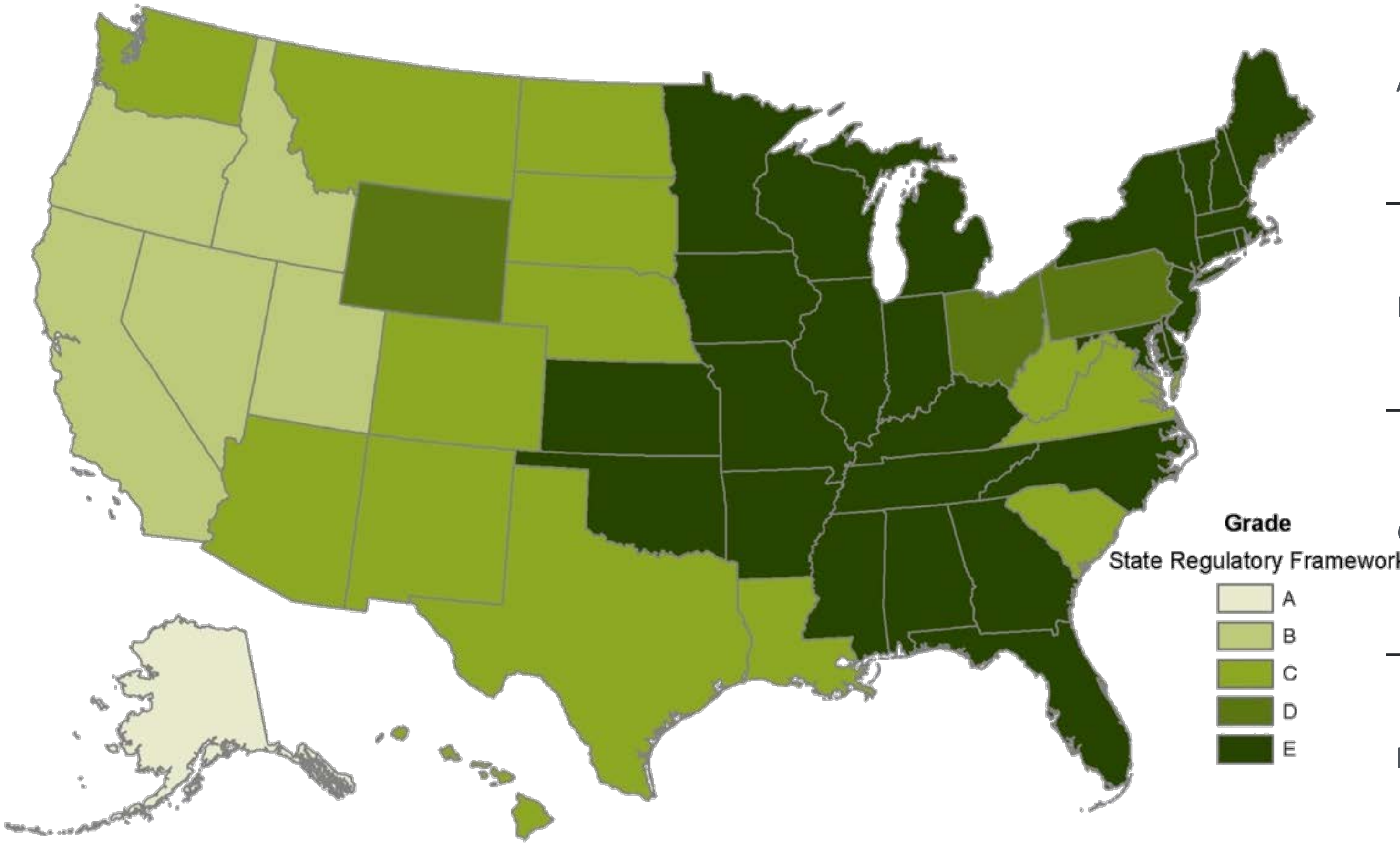
4.2.2 Permitting Sub-Attribute: Regulatory Framework: State

- The state regulatory framework sub-attribute grades and map (next slide) address the relative sophistication of the permitting regulations and knowledge within the state specific to geothermal development. 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).
- The BET stated that while a lack of geothermal regulations would not prevent development, it would likely be *a significant barrier* potentially preventing them from pursuing development.

- **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.

Mt. Princeton Hot Springs is home to geothermal direct use.

4.2.2 Permitting Sub-Attribute:
Regulatory Framework: State



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
D	State/county has a definition of geothermal resources but does not have permitting regulations
E	State/county does not have any geothermal regulations

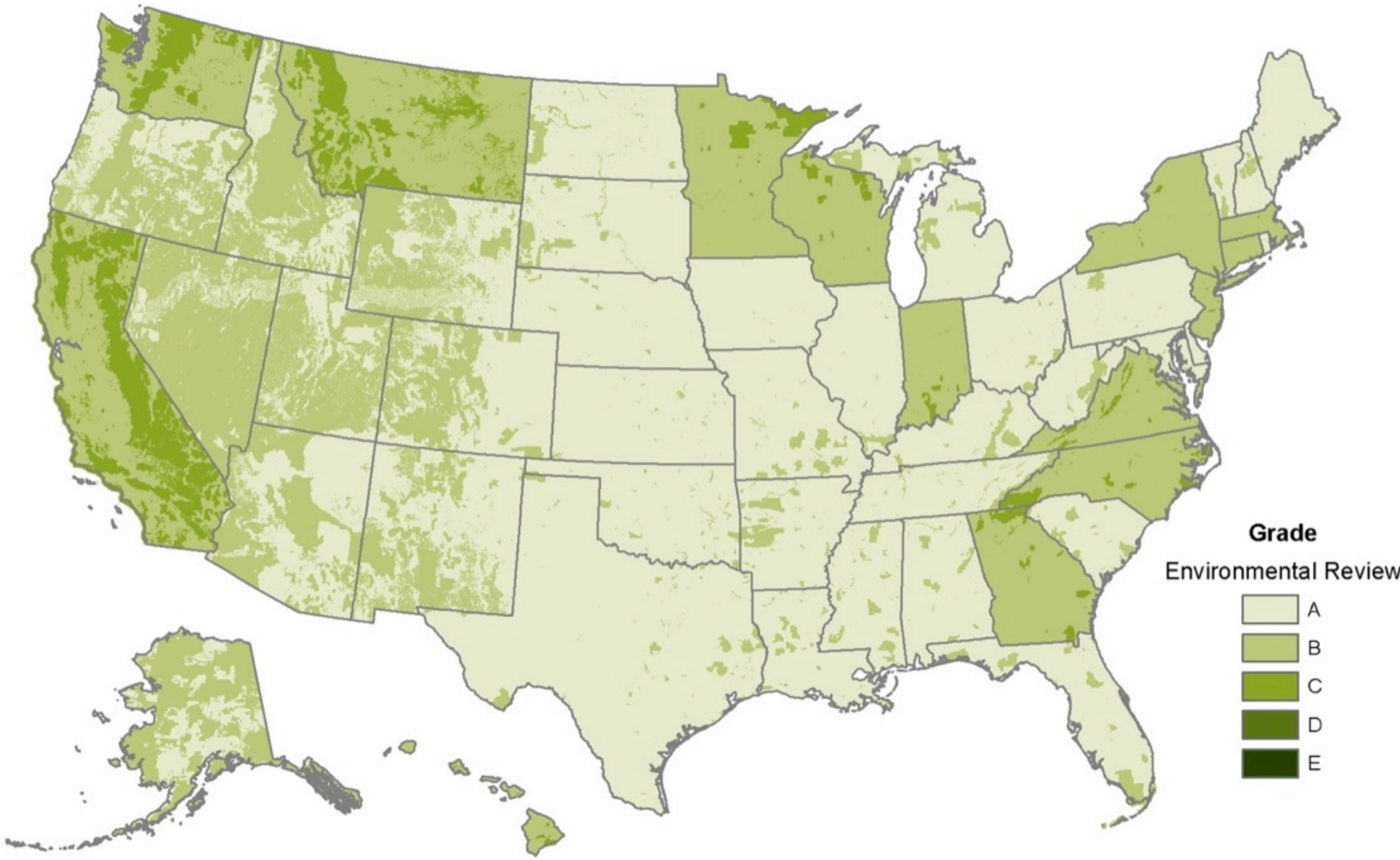
All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.2.2 Permitting Sub-Attribute: Environmental Review Process

- Geothermal projects may have to go through the environmental review process as many as six times, and depending on the type of review (e.g., categorical exclusion, environmental assessment, environmental impact statement) and complexity of the proposed activity, each review may take anywhere from 1 month to 3 or more years (Young et al. 2014).
- The environmental review process sub-attribute grades and map (next slide) 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.

- **Example:** The Bottle Rock Power Steam Project, a geothermal project located in Lake County, California, on BLM-managed public lands, required compliance with both the National Environmental Policy Act (NEPA) and the California Environmental Quality Act (CEQA). In this instance, the BLM served as the lead agency under NEPA and Lake County as the lead agency under CEQA in development of a joint Environmental Impact Report/Environmental Assessment (County of Lake 2010).

4.2.2 Permitting Sub-Attribute: Environmental Review Process

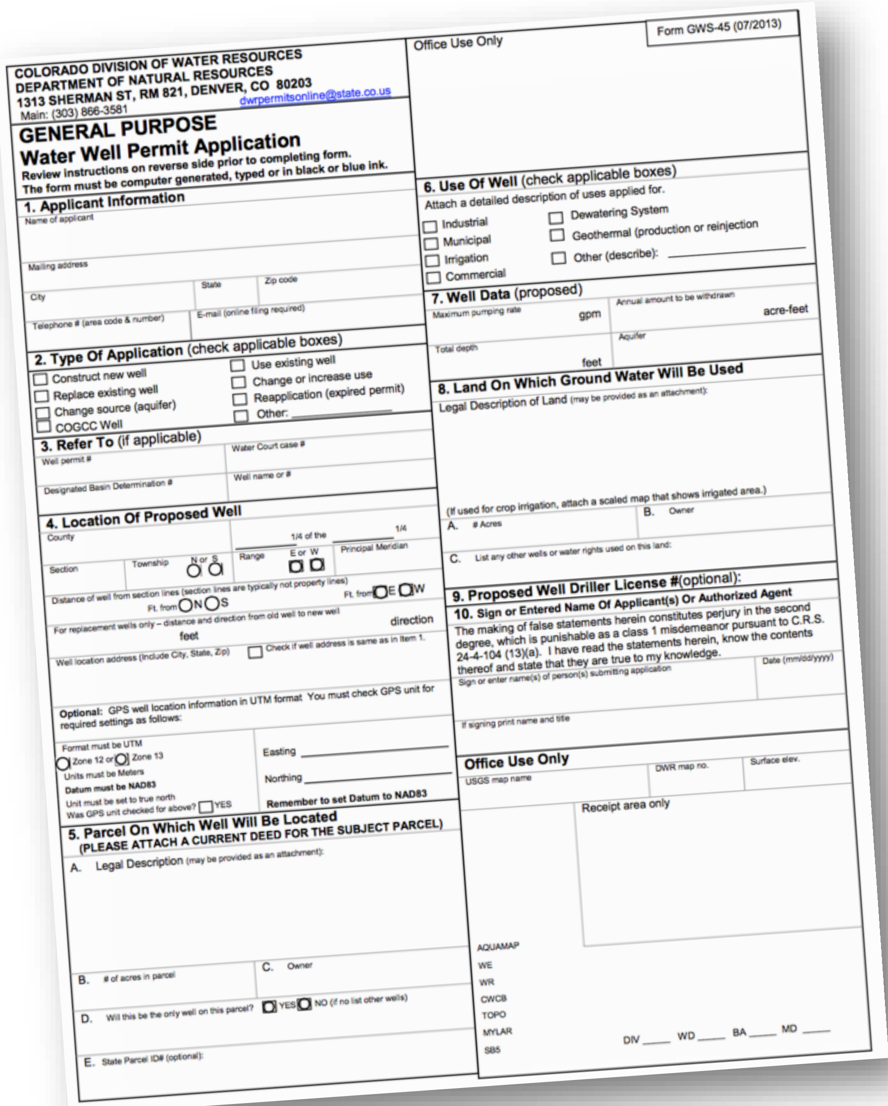


A	Project is not subject to any federal or state environmental review process for any permits required for the project or has completed necessary environmental reviews.
B	Project is subject to **one** federal or state environmental review process for any permits required for the project.
C	Project is subject to **two** federal or state environmental review processes for any permits required for the project.
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**.
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**.

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. In addition, 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.

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.2.2 Permitting Sub-Attribute:
Ancillary Permits



COLORADO DIVISION OF WATER RESOURCES
DEPARTMENT OF NATURAL RESOURCES
1313 SHERMAN ST, RM 821, DENVER, CO 80203
Main: (303) 866-3581 dwrpermitsonline@state.co.us

Office Use Only

Form GWS-45 (07/2013)

GENERAL PURPOSE
Water Well Permit Application
Review instructions on reverse side prior to completing form.
The form must be computer generated, typed or in black or blue ink.

1. Applicant Information
Name of applicant
Mailing address
City | State | Zip code
Telephone # (area code & number) | E-mail (online filing required)

2. Type Of Application (check applicable boxes)
☐ Construct new well ☐ Use existing well
☐ Replace existing well ☐ Change or increase use
☐ Change source (aquifer) ☐ Reapplication (expired permit)
☐ COGCC Well ☐ Other:

3. Refer To (if applicable)
Well permit # | Water Court case #
Designated Basin Determination # | Well name or #

4. Location Of Proposed Well
County | 1/4 of the | 1/4
Section | Township N or S | Range E or W | Principal Meridian
Distance of well from section lines (section lines are typically not property lines)
Ft. from N S | Ft. from E W
For replacement wells only – distance and direction from old well to new well
feet | direction
Well location address (Include City, State, Zip) ☐ Check if well address is same as in Item 1.
Optional: GPS well location information in UTM format You must check GPS unit for required settings as follows:
Format must be UTM
Zone 12 or Zone 13 | Easting
Units must be Meters
Datum must be NAD83 | Northing
Unit must be set to true north
Was GPS unit checked for above? ☐ YES | Remember to set Datum to NAD83

5. Parcel On Which Well Will Be Located
(PLEASE ATTACH A CURRENT DEED FOR THE SUBJECT PARCEL)
A. Legal Description (may be provided as an attachment):
B. # of acres in parcel | C. Owner
D. Will this be the only well on this parcel? ☐ YES ☐ NO (if no list other wells)
E. State Parcel ID# (optional):

6. Use Of Well (check applicable boxes)
Attach a detailed description of uses applied for.
☐ Industrial ☐ Dewatering System
☐ Municipal ☐ Geothermal (production or reinjection)
☐ Irrigation ☐ Other (describe):
☐ Commercial

7. Well Data (proposed)
Maximum pumping rate gpm | Annual amount to be withdrawn acre-feet
Total depth feet | Aquifer

8. Land On Which Ground Water Will Be Used
Legal Description of Land (may be provided as an attachment):
(If used for crop irrigation, attach a scaled map that shows irrigated area.)
A. # Acres | B. Owner
C. List any other wells or water rights used on this land:

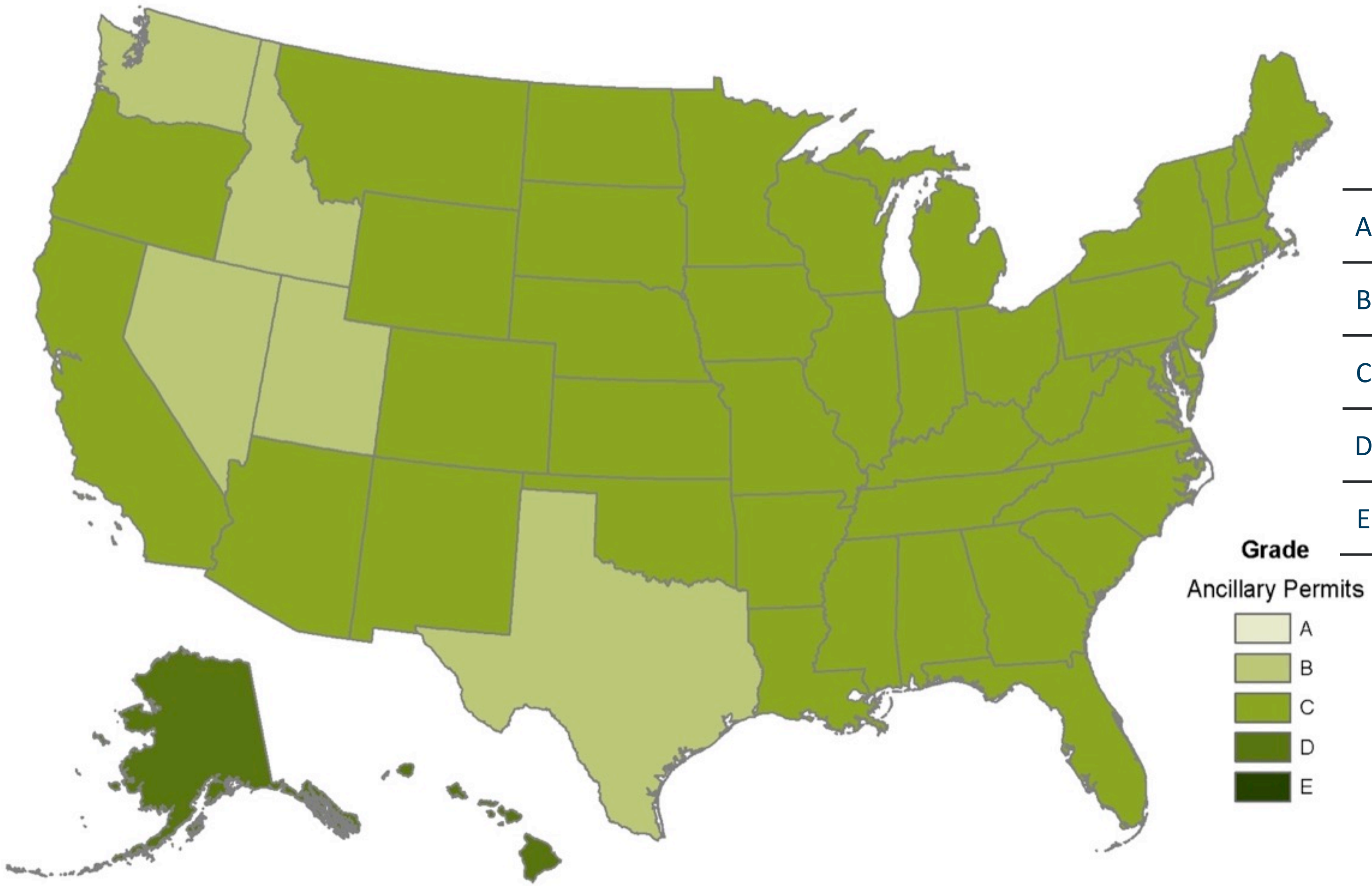
9. Proposed Well Driller License #(optional):

10. Sign or Entered Name Of Applicant(s) Or Authorized Agent
The making of false statements herein constitutes perjury in the second degree, which is punishable as a class 1 misdemeanor pursuant to C.R.S. 24-4-104 (13)(a). I have read the statements herein, know the contents thereof and state that they are true to my knowledge.
Sign or enter name(s) of person(s) submitting application | Date (mm/dd/yyyy)
If signing print name and title

Office Use Only
USGS map name | DWR map no. | Surface elev.
Receipt area only
AQUAMAP
WE
WR
CWCB
TOPO
MYLAR
SB5
DIV ___ WD ___ BA ___ MD ___

- 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.
- The ancillary permit sub-attribute grades and map (next slide) 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).

4.2.2 Permitting Sub-Attribute: Ancillary Permits



	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

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.2.3 Permitting: Influence on Potential

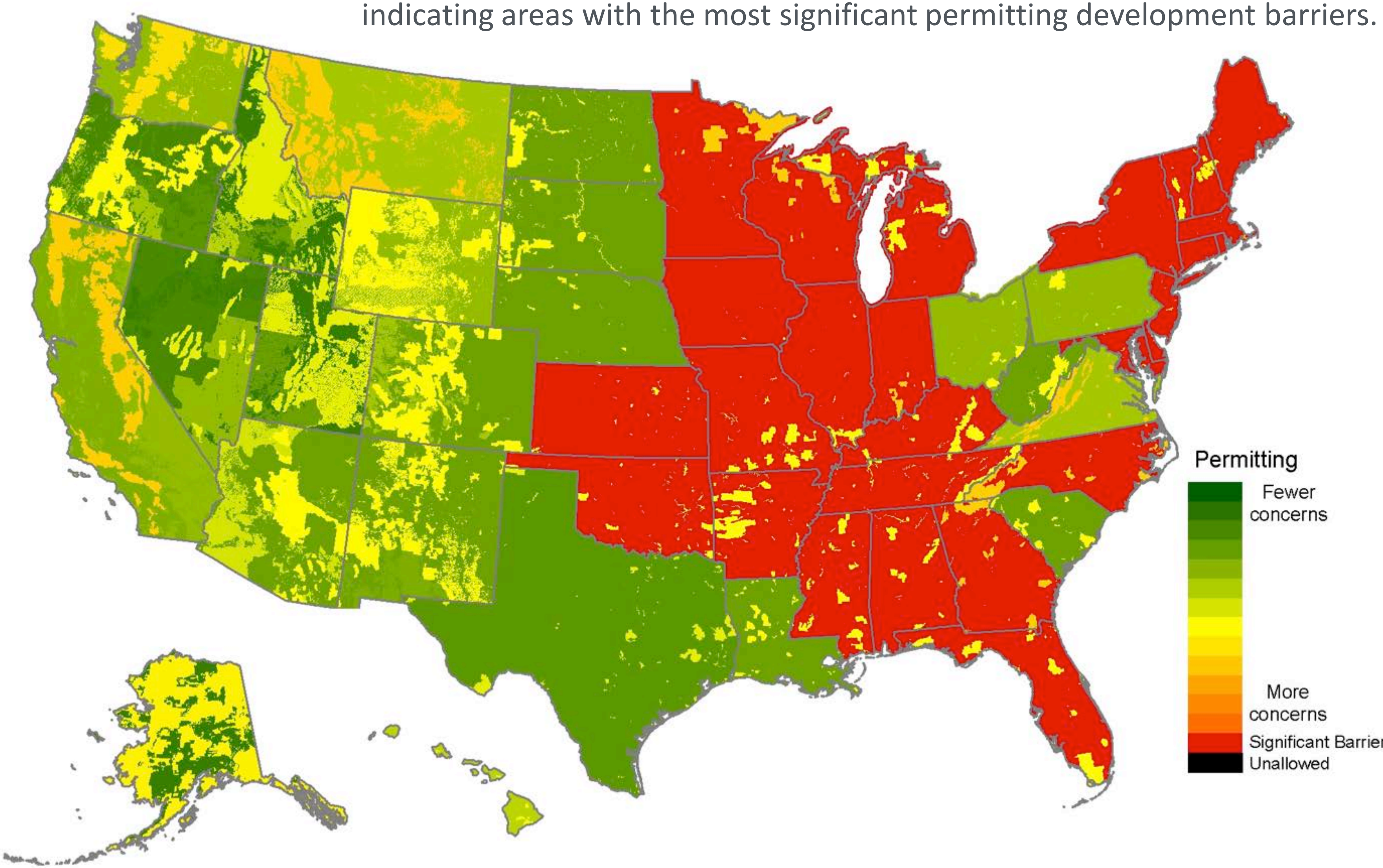
- This table provides a summary of flagged, significant barrier, and unallowed grades for each of the permitting sub-attributes.
- None of the four sub-attributes identify lands that are legally unallowed for geothermal development.
- Three of the four sub-attributes show significant barriers and/or flagged grades, indicating permitting contributes to geothermal development delays.

1. Sub-Attributes Analyzed	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*
Ancillary Permits	--	--	--

Note: **Bolded** grades indicate data were available for mapping this sub-attribute. *Italicized* grades indicate that no data were available for mapping.

4.2.3 Permitting: Influence on Potential

This map summarizes all four permitting sub-attributes into a single map, indicating areas with the most significant permitting development barriers.



All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.2.4 Permitting: Improvement Scenarios

Scenarios	Description – Bottoms-Up Story	Model Inputs			
		Resource Type	Permit Processing Costs	Project Timeline (Years)	Undiscovered Discovery Rate
BAU	• Current delays caused by multiple environmental processes, delays in transmission studies, and obtaining PPAs. • Timelines will increase with no mitigation.	Identified	\$250k	8	---
		Undiscovered	\$250k	8	1%
		EGS	\$250k	10	---
SCENARIO 1: Low improvement case (2-year improvement)	• Centralized/coordinated 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.	Identified	\$250k	6	---
		Undiscovered	\$250k	6	2%
		EGS	\$250k	7	---

SCENARIO 2: Disruptive Improvement Scenario (i.e., GeoVision - Improved Regulatory Timelines (IRT)) (4-year improvement)	• Low case, PLUS:
	• Categorical exclusions for:
	  • Limited surface disturbance
	  • Geothermal exploration and resource confirmation
		Identified	\$50k	4	---

		Undiscovered	\$50k	4	3%
		EGS	\$50k	5	---

4.2.4 Permitting Improvement Scenario:
Low Improvement: Centralized Permitting Office

- Centralized/coordinated federal permit offices and state permit coordination offices can be an effective tool for coordinating the required 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). A 2008 report analyzing these programs 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 categorical exclusions, and expanded use of strategies to process more permit approvals through a single NEPA action (BLM 2008).
- 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).

4.2.4 Permitting Improvement Scenario:
Low Improvement: Centralized Permitting Office

- This improvement scenario analyzes the impacts of the creation of a centralized/coordinated federal permitting office in the western United States for geothermal development and an expanded use of state permit coordination offices. Benefits of a centralized/coordinated federal permitting office for geothermal could include:
  - Creating efficiencies by repetition and development of expertise by core geothermal staff
  - Allowing for efficient use of BLM resources by reducing duplication of staff capabilities (e.g., instead of training one person in five areas, train a few employees only in geothermal)
  - Creating teams with common skills/capabilities to accommodate staff unavailable due to work travel, vacation, and holiday schedules
  - Developing a dedicated geothermal staff and skills that would allow for more efficient completion of geothermal-specific projects (e.g., updating regulations, agency orders).
- We estimate that a combination of a geothermal centralized/coordinated federal permitting office and expansion of state permit coordination offices could reduce timelines from the current GETEM estimate of 8 years to 6 years for hydrothermal resources and 7 years for EGS resources.

Attribute: Permitting
Low Improvement Scenario:
Centralized/Coordinated Permitting Office

This low improvement scenario analyzes the impacts of the creation of a centralized/coordinated federal permitting office in the western United States for geothermal development and an expanded use of state permit coordination offices.

4.2.4 Permitting Improvement Scenario: Disruptive Improvement (IRT): CX for Exploration Drilling

- As discussed in Section 2.2.2.3 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.
- The type of review process required [e.g., CX, EA, environmental impact statement (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 take significantly less time to complete than an EA or 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 specific to geothermal development, which applies to geothermal exploration operations permitted under a Notice of Intent (NOI) to Conduct Geothermal Resource Exploration Operations as long as the exploration operations include no temporary or new surface disturbance including access roads and well pads (DOI 516 DM 11.9).

Attribute: Permitting
Disruptive Improvement Scenario (IRT):
CX for Exploration Drilling

This disruptive improvement (IRT) scenario combines the centralized/coordinated permitting office with the development of a CX for exploration/resource confirmation drilling to reduce exploration timelines by 4 years.

4.2.4 Permitting Improvement Scenario:
Disruptive Improvement (IRT): CX for Exploration Drilling

- EPAct 2005 § 390 provided statutory CXs for oil and gas development on federally managed public lands. These CXs are not subject to extraordinary circumstances review.
- The draft version of EPAct 2005 included CXs for geothermal development, but they were removed from the final legislation.
- The EPAct 2005 § 390 CXs applicable to oil and gas development include:
  - Individual surface disturbances 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 5 years prior to the date of spudding the well
  - Drilling an oil or 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 reasonably foreseeable activity, so long as such plan or document was approved within 5 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 5 years prior to the date of placement of the pipeline
  - Maintenance of a minor activity, other than any construction or major renovation or building or facility (EPAct § 390).
- The expansion of 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 CXs could increase the rate of discovery for undiscovered geothermal resources from 1% per year to 3% per year due to shortened permitting and environmental review timeframes.

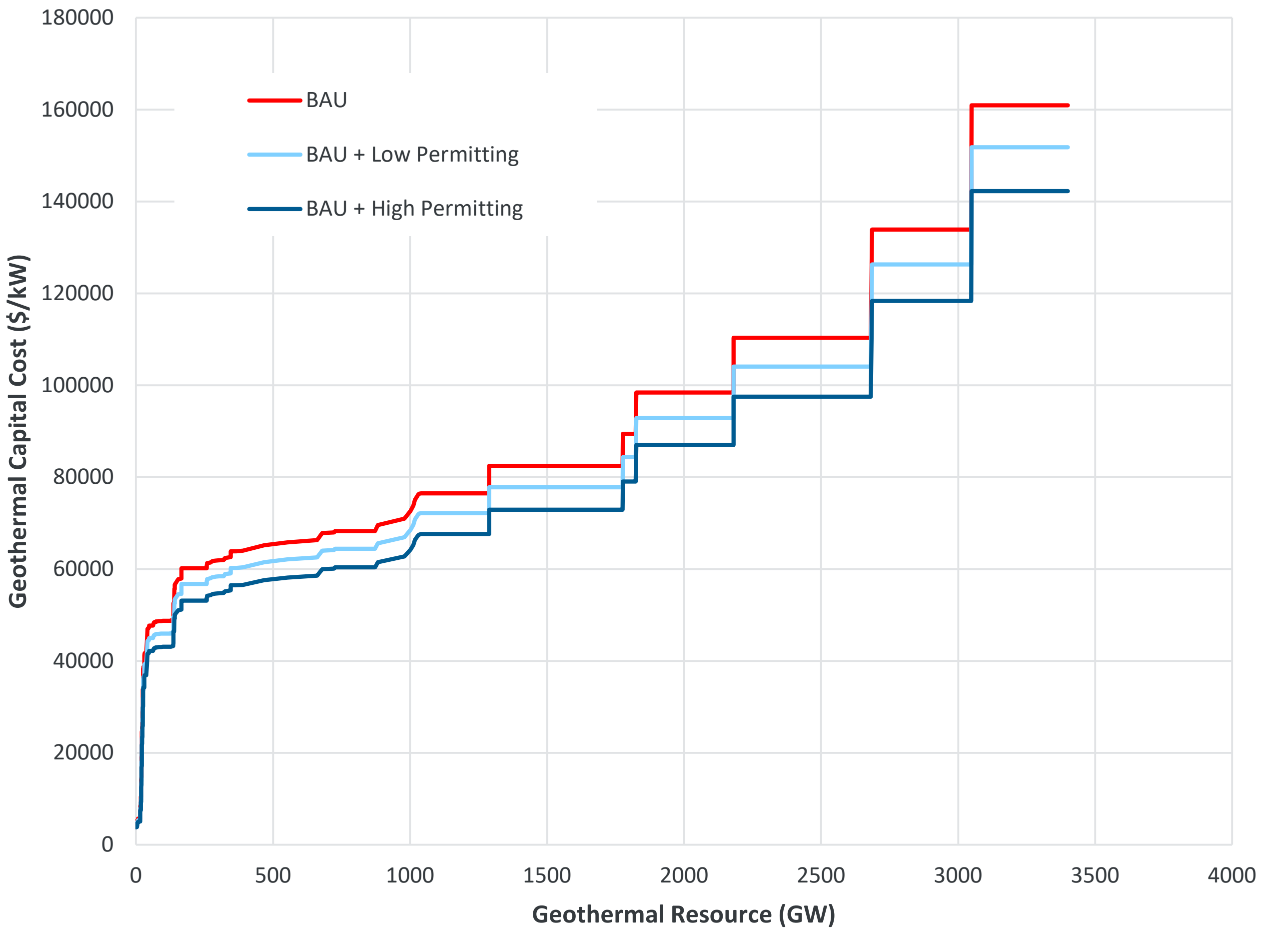
4.2.5 Permitting: Model Inputs

# years	0	1	2	3	4	5	6	7	8	9	Comments
Hydrothermal											
4	PDE	EXDR	WFDR	PP							**Scenario 2** - likely the fastest scenario (no permitting delays); streamlined federal permitting mandates; and/or new well CX and/or through-put rules
6	PDE	--	EXDR	--	WFDR	PP					**Scenario 1** – centralized/coordinated permitting office
8	PDE	--	EXDR	--	--	--	WFDR	PP			**BAU Now**
EGS											
5	PDE	EXDR	WFDR	STIM	PP						**Scenario 2 (IRT)** - likely the fastest scenario (no permitting delays)
7	PDE	--	EXDR	--	WFDR	STIM	PP				**Scenario 1** -average timeframe (unless technical team has additional timelines)
10	PDE	--	--	EXDR	--	--	--	WFDR	STIM	PP	**BAU** - though environmental reviews for stimulation may cause additional delays, we assume EGS projects have some geographic flexibility and can move to avoid other potentially time-consuming environmental concerns

n/a *leasing and rentals pre-exploration and not accounted for in this timeline because they are not often financed.*
PDE pre-driling exploration, including TGH with CXs - may or may not be financed
EXDR exploration/confirmation drilling
WFDR well-field drilling
STIM stimulation (for EGS)
PP power plant
n/a *transmission - when does this start getting financed in ReEDS? Not included in these scenarios; we assume ReEDS handles this is during the PP phase*

4.2.5 Permitting: Model Inputs

Description of supply curve impacts



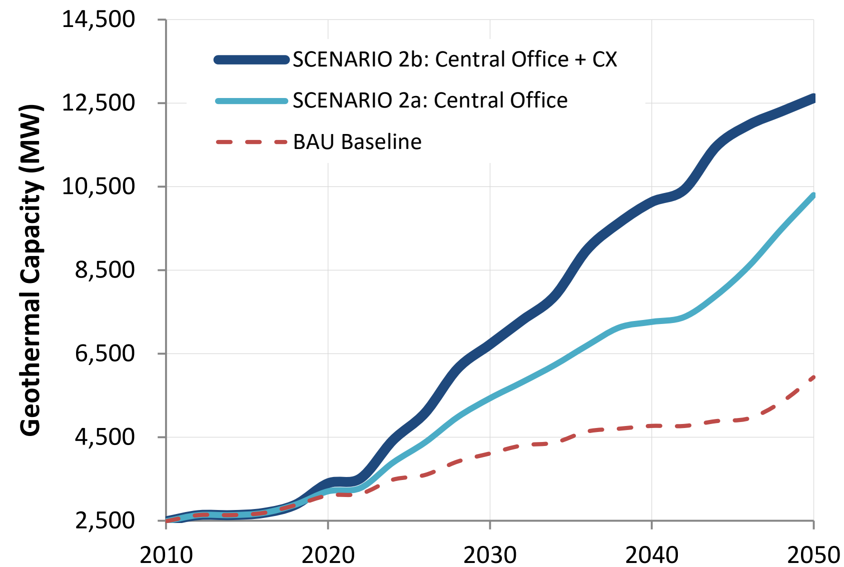
2. Model Input Affected
Supply
Cost
Timeline
Demand
Technology Selection
Transmission

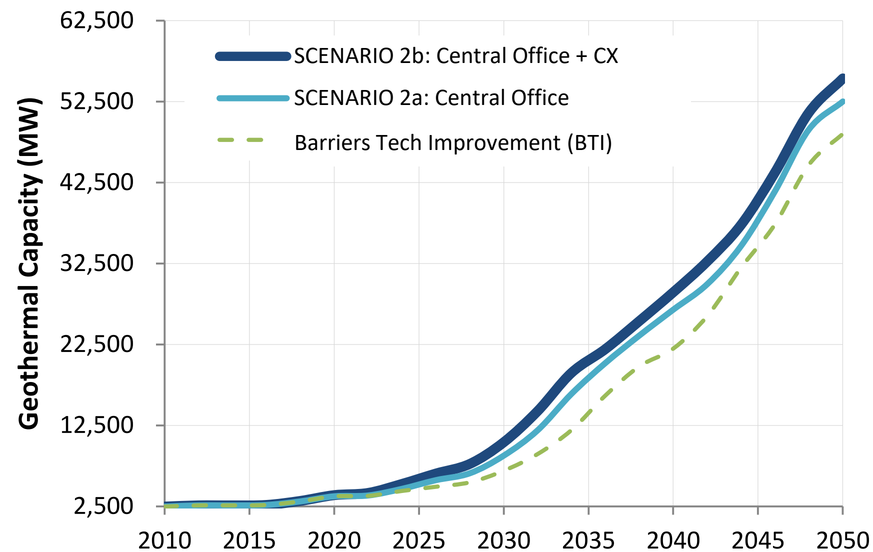
Shortening time frames shifts the supply curves down, reflecting lower costs for financing development projects.

4.2.5 Permitting: Model Results

Improvement	over BAU	over BIT
2a: Central Permitting Office	4.4 GW (74%)	4.0 GW (8%)
2b: Central Office + CX (IRT)	6.7 GW (113%)	6.8 GW (14%)

- Though we present potential permitting improvement scenarios, in the model, these scenarios did not model specific permit improvements but instead modeled **improvement in timelines**, which improved finance and therefore cost.
- Many activities—from permitting to land access to drilling advancements—can improve timelines and should be considered when trying to improve project timelines.
- Timeline/cost improvements have a larger impact in the BAU scenario than in the BTI scenario, which already models significant cost improvements.





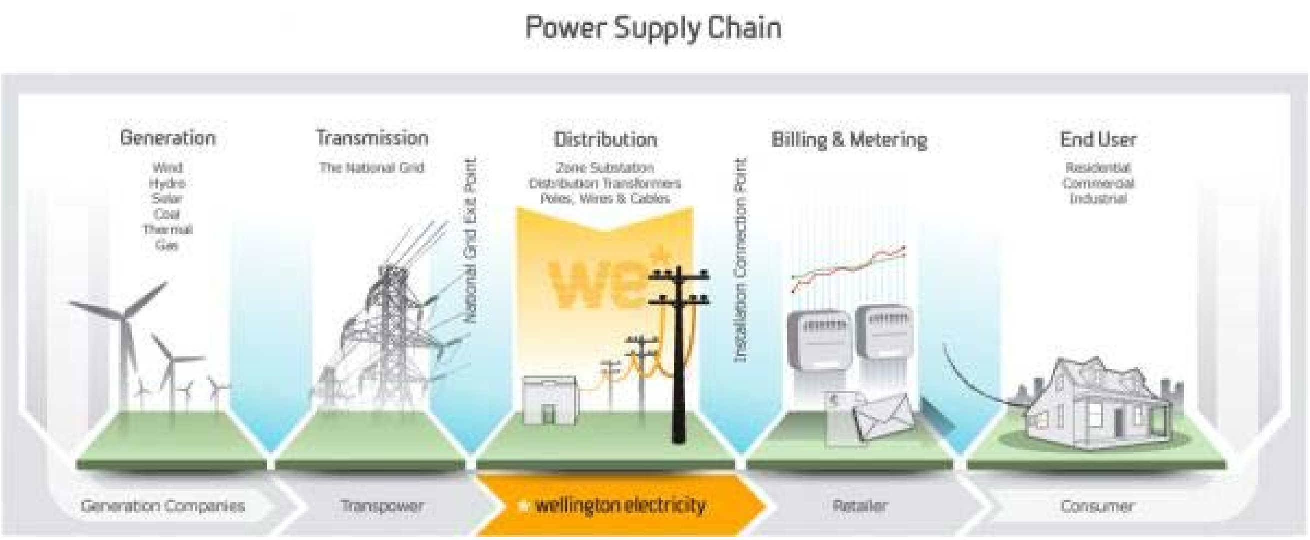
4.3.1 Barrier Overview: Market

Developers overwhelmingly commented that power market—the ability to obtain a competitive PPA—was one of the largest drivers to geothermal project development. Wall and Young (2016) state that obtaining PPAs is the largest barrier to geothermal projects under development in the United States. This was confirmed by members of the BET. To obtain a PPA, a developer has to provide (among other things) two pieces of information:

1. A demonstrated resource (varies by technology)
2. An interconnection study/agreement (typically $50k-$150k for any technology).

Demonstrating the resource for solar or wind is not very expensive. However, developers told us that for geothermal, demonstrating the resource is very expensive and requires multiple surveys (e.g., geophysical surveys, thermal gradient holes, full-size diameter drilling well). Each of these activities is $1M or more, resulting in $5M-$10M to demonstrate a geothermal resource. Purchasers often require geothermal developers to demonstrate the size of the potential resource using a reservoir model and have third-party verification of the resource.

Therefore, geothermal developers have to invest significantly more money into a project than a solar or wind project before knowing whether a PPA can be obtained. Because of this sunk pre-PPA cost, it is important to geothermal developers that a competitively priced PPA with appropriate terms and conditions be obtainable in order to avoid losses and to proceed in a timely manner.



4.3.1 Barrier Overview: Market

One of the major messages of the 2016 Baseload Energy Summit (GEA 2016) was that developers such as geothermal, hydropower, and biomass felt that utilities did not know how to appropriately value the baseload nature of these resources and account for potentially additional costs of operating a grid with high levels of variable renewable energy, such as wind and solar. Of particular concern are lower capacity factors of geothermal plants, which can occur in systems with higher levels of variable RE. When variable RE generation is high relative to load, power plants with higher operating costs, such as geothermal, are potentially turned down and no longer operate as baseload plants (i.e., plants that are dispatched at constant or near-constant levels). While in the past PPAs were typically written to pay geothermal based on its full potential output even if the plants are dispatched lower, the trend in contracting now is to pay only based electricity needed for the grid.

The California Public Utilities Commission (CPUC) issued a ruling in furtherance of its Long Term Procurement Planning (LTPP) rulemaking directing Southern California Edison to complete a study to model operating costs but have not been successful to date in getting these system network models to converge accurately (CEERT 2016). Developers felt that a long-term planning analysis that properly values the grid services they provide—and education of utilities of these values—were critical to obtaining appropriate PPA prices for baseload power generators. We identified four sub-attributes that most significantly contributed to the ability to participate in the power market (described in more detail in subsequent slides):

- Market demand
- Wholesale price of electricity
- Policies
- Incentives.

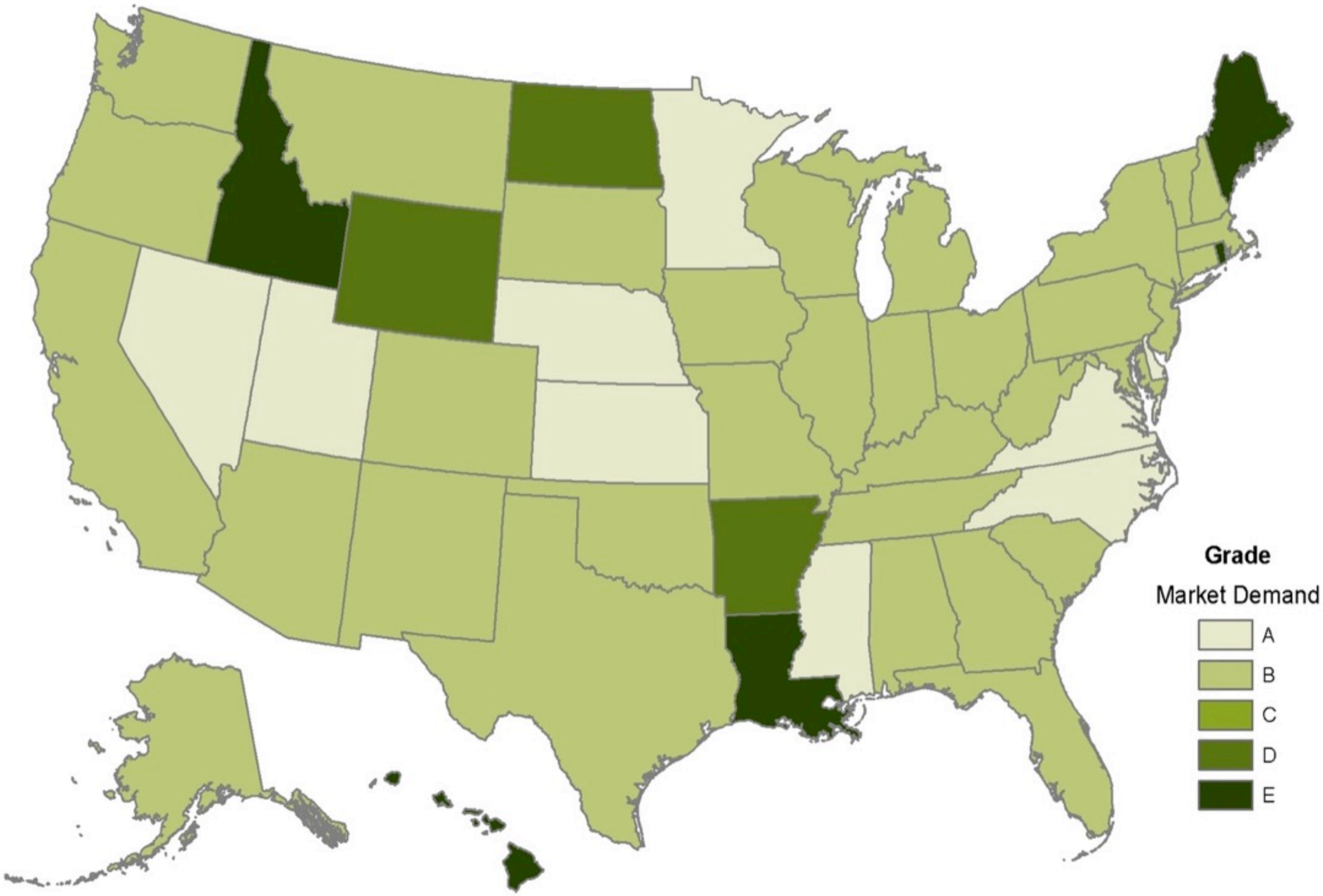
4.3.2 Market Sub-Attribute: Market Demand

Assessing future demand for additional electricity is important to identifying markets that may have an appetite for geothermal electricity. Future demand is a direct function of direct increases in demand, reductions due to increases in energy efficiency and demand response, and changes in a region's current electricity portfolio through planned retirements.

To evaluate the market demand sub-attribute, we:

- Calculated a 3-year cumulative annual grow rate for electricity demand by state using Energy Information Administration (EIA) electricity consumption data from 2011 to 2014
- Calculated cumulative annual growth rate for projected electricity consumption for 2015-2025, using 2015 EIA Annual Energy Outlook data
- Evaluated planned retirements of coal and natural gas power plants using the ASEA Brown Boveri Energy Velocity Suite power plant database.

4.3.2 Market Sub-Attribute: Market Demand



A	Strong current & long-term electricity demand (either usage increase or from retirements) **(PPA price: >$100/MWh)**
B	Current demand & strong long-term demand (either usage increase or retirements) **(PPA price: > $80/MWh-$100/MWh)**
C	Moderate current & long-term demand (either usage increase or retirements) **(PPA price: > $60/MWh-$80/MWh)**
D	Current & long-term demand uncertain OR peak load only (e.g., high solar/wind states) **(PPA price: > $40/MWh-$60/MWh)**
E	Neither current nor long-term demand (e.g., energy market shrinking) **(PPA price: <$40/MWh)**

Electricity markets are generally analyzed on smaller scales than the state level. Further analysis could be done to analyze more regionally.

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

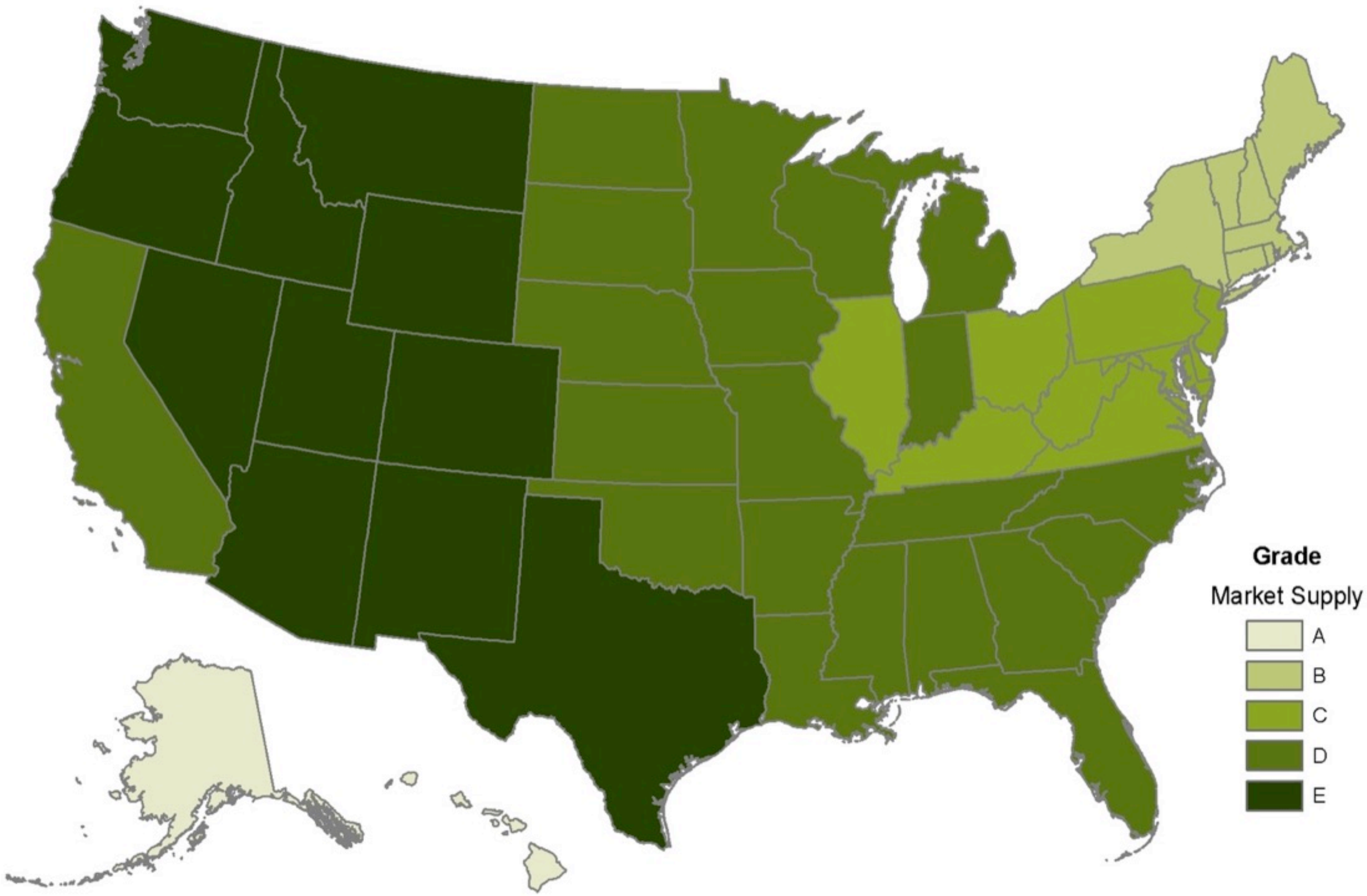
4.3.2 Market Sub-Attribute:
Wholesale Price of Electricity

Wholesale electricity prices help to better understand the price point a geothermal power plant may need to reach to make a profit. The wholesale electricity price generally reflects the marginal cost of generating electricity and delivering it through the transmission system. The average annual wholesale electricity price is closely related to the PPA price for a geothermal power plant.

To determine the wholesale electricity price for geothermal power plants, we:

- Calculated the average PPA price for 16 available PPA contracts for geothermal power plants placed between 1981 and 2015 for projects ranging from 2 to 50 MW (price average was 0.0781/kWh)
- Compared PPA prices to the regional 2015 wholesale electricity price reported by EIA.

4.3.2 Market Sub-Attribute:
Wholesale Price of Electricity



Cost of supplying geothermal to the market relative to weighted average of other technologies on the grid

A	**Slightly less:** Regional 2015 wholesale price **>= 1x** geothermal LCOE
B	**More:** Regional 2015 wholesale price between **1 and 0.6x** geothermal LCOE
C	**More:** Regional 2015 wholesale price between **0.6x and 0.5x** geothermal LCOE
D	**More:** Regional 2015 wholesale price between **0.5x and 0.4x** geothermal LCOE
E	**More:** Regional 2015 wholesale price **<= 0.4x** geothermal LCOE

**avg for 20-MW plant; $0.0781/kWh*
**US avg = 9.84 cents/ kWh*

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.3.2 Market Sub-Attribute: Market Policies

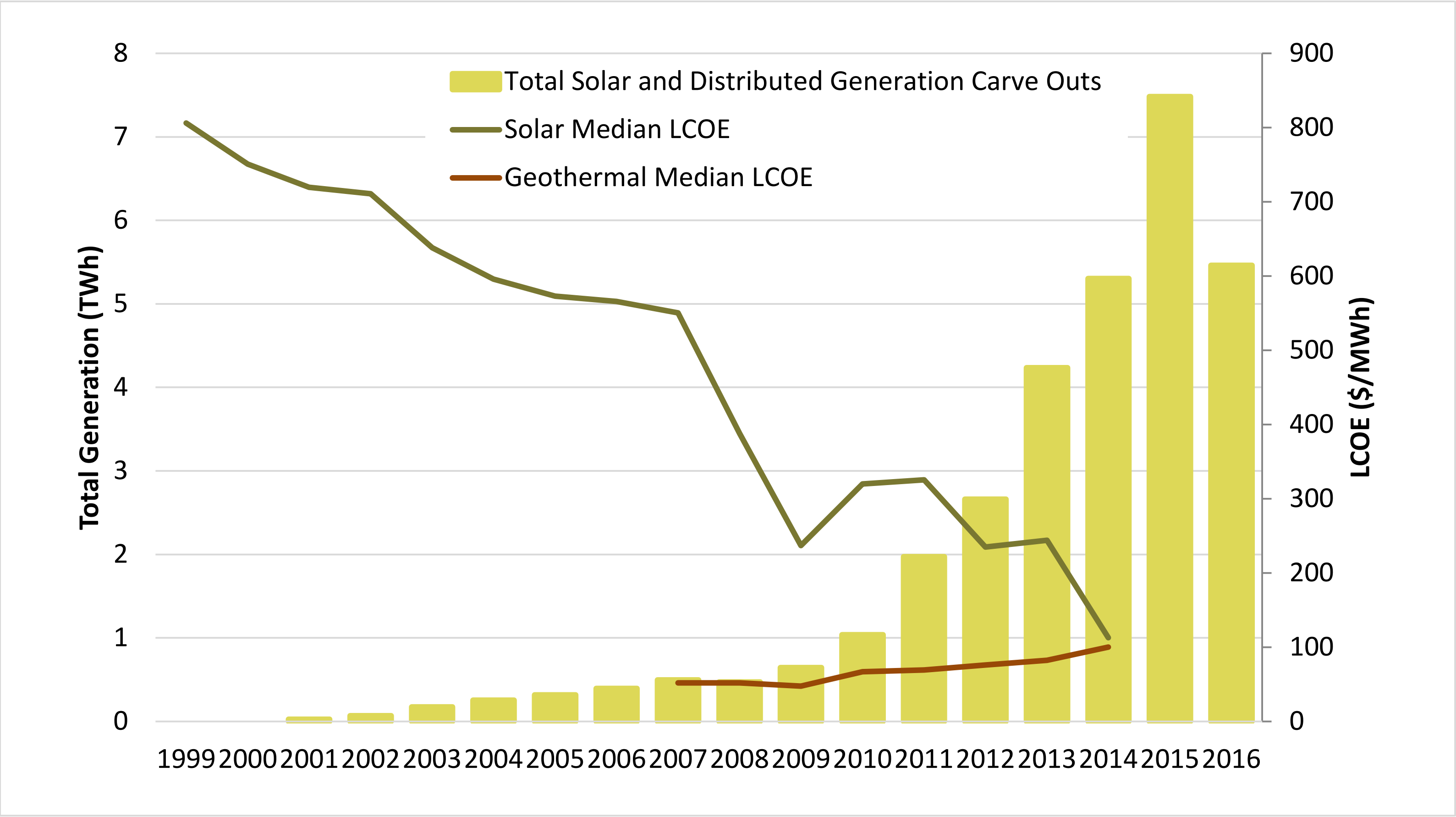
Renewable energy policies include feed-in-tariffs (FITs), renewable portfolio standards (RPSs), and carbon emission limits. FITs and RPSs are the most widely adopted renewable energy policies around the world (Cox and Esterly 2016). However, in the United States, state RPS requirements have been the most impactful state policy driver for renewable energy deployment, with more than half of all renewable energy capacity additions since 2000 serving RPS demand (Mai et al. 2016).

The majority of RPS programs in the United States are driven by generation (i.e., MWh), but some are capacity-driven (MW nameplate capacity), which treats generation sources with different capacity factors equally, despite a difference in MWh delivered (see Nevada SB 123 2013). In addition, some states have employed set-aside requirements or RPS multipliers for certain types of renewable energy to encourage specific generation sources.

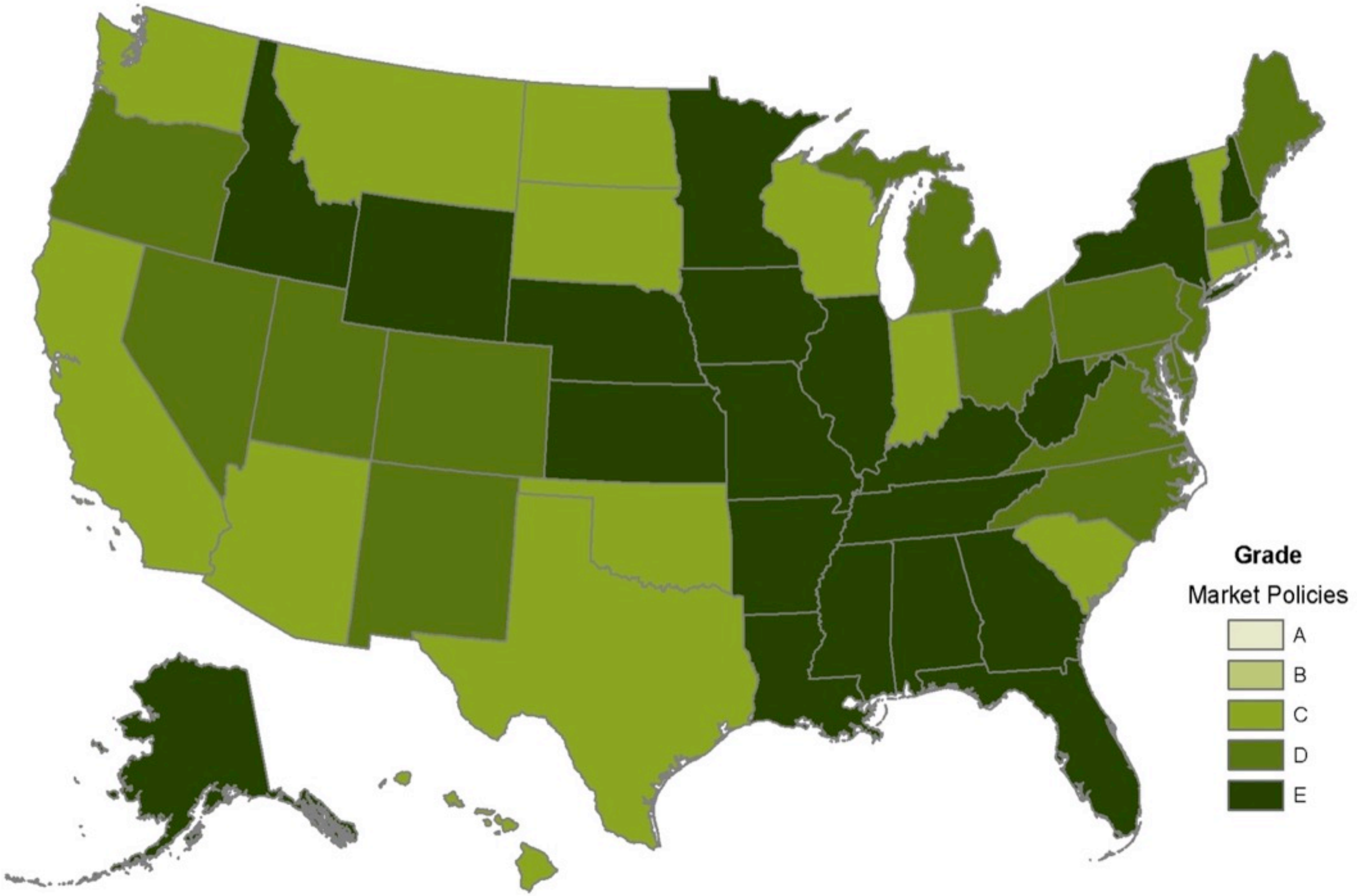
Example: Oregon’s RPS had a 2.0x multiplier for utilities that use solar photovoltaics (PV) to meet the state RPS through 2015 [ORS 757.375(2)].

4.3.2 Market Sub-Attribute:
Market Policies

Solar and distributed generation carve-out requirements from 1998–2016 (Barbose 2017) and median LCOE for solar and geothermal (OpenEI 2014; NREL 2016)



4.3.2 Market Sub-Attribute: Market Policies



A	Feed–in tariff for geothermal (standard offer contracts)
B	Interconnection set-aside or RPS or state purchase requirement **specific for geothermal**
C	State renewable purchasing requirements or RPS—**not preferential to a particular renewable**
D	State purchasing requirements or RPS—**with preferential consideration or set-asides for non-geothermal renewables**
E	No policies beneficial to renewables (no RPS)

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.3.2 Market Sub-Attribute:
Market Incentives

Financial policy incentives for energy deployment include tax incentives such as:

- Federal investment tax credit (ITC) and production tax credit (PTC) for renewables
- Federal exploration incentives for oil and gas
- State financial incentives such as grant-to-loan programs (see California PRC 3800 et seq.) that lower upfront exploration risk (see Speer et al. 2014; Sanyal et al. 2016).

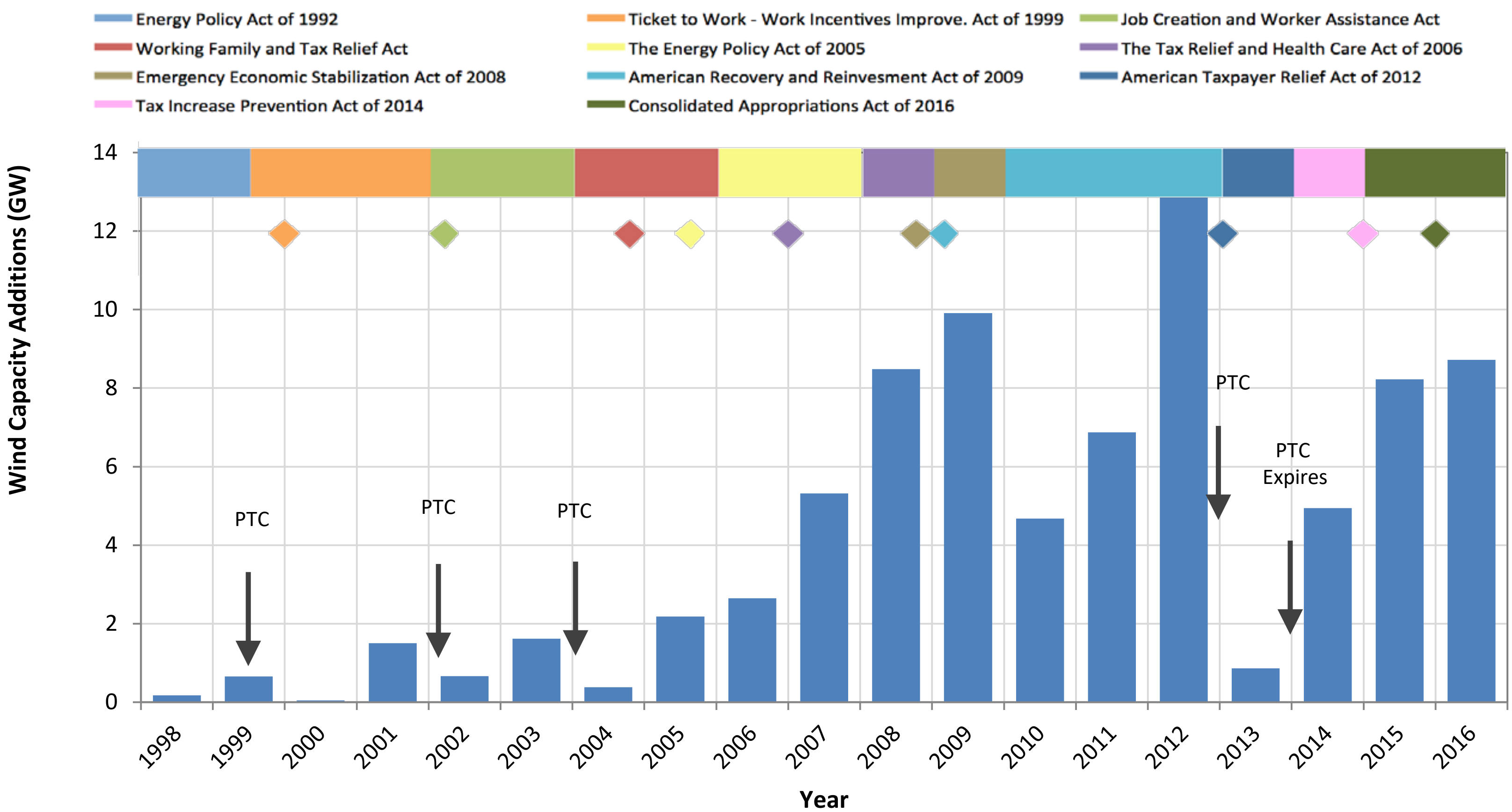
Geothermal developers interviewed for this project suggested that the ITC has been more helpful for geothermal power plant development than the PTC* due to the development timelines associated with geothermal projects.

The geothermal ITC is currently fixed at 10%, while the PTC was phased out for geothermal power plants not put into service before the end of 2016 (see 26 USC § 48 and Consolidated Appropriations Act of 2016).

*The ITC allows developers to recover capital costs more immediately after construction, while the PTC is earned based on energy production after the plant is operating.

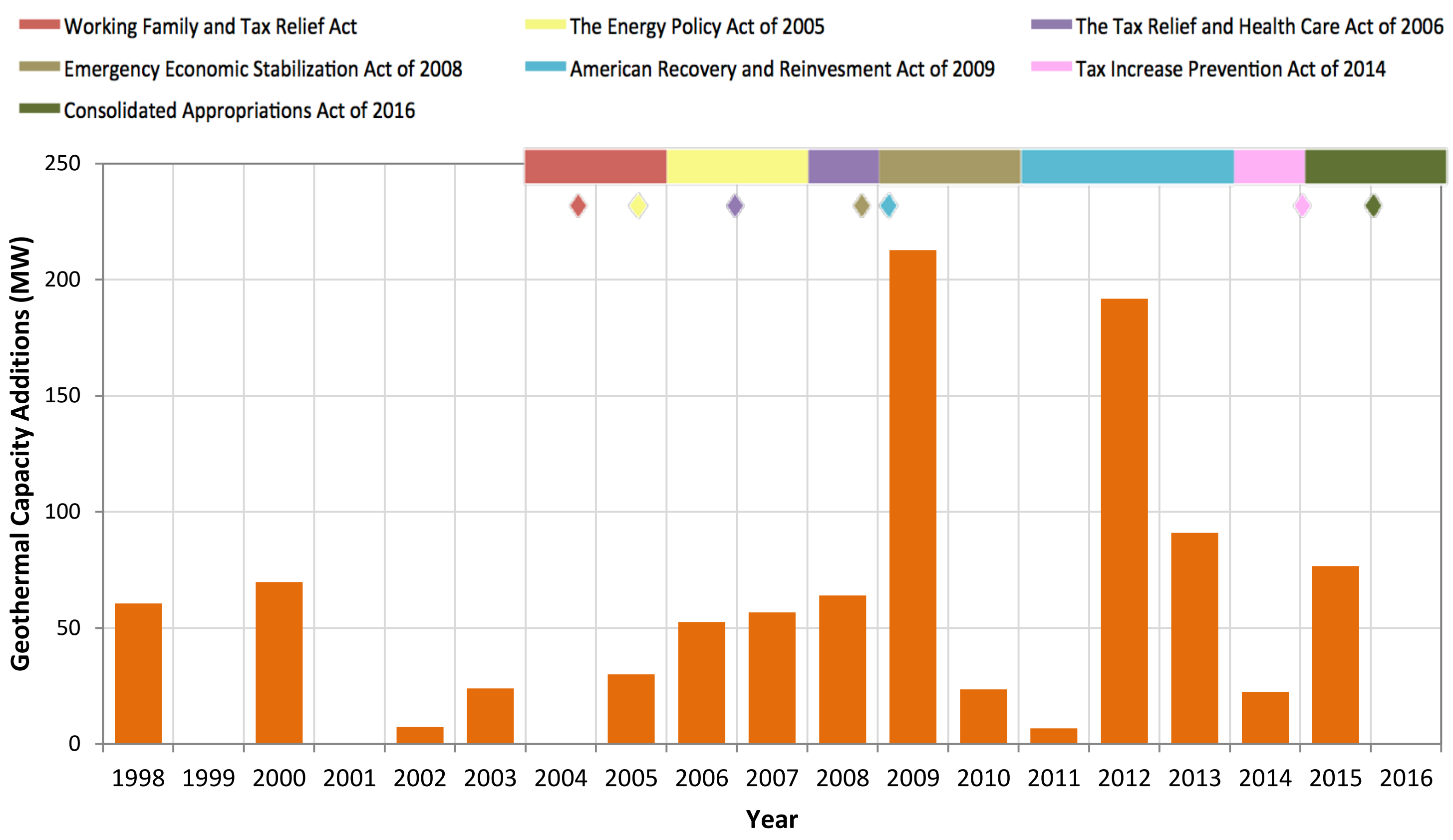
4.3.2 Market Sub-Attribute: Market Incentives

The effect of incentives on wind deployment in the United States between 1997 and 2016. Wind capacity additions each year are shown in blue columns. The bar graph at the top shows when policies were enacted (diamonds) and the eligibility window (corresponding color bar). The figure suggests a strong correlation between tax credit availability and wind deployment. When the tax credit expires, a drop off in wind development is observed. Because of the short development timeframe for wind projects (3 years), these projects are better positioned to take advantage of short PTC extension timeframes. Deployment data: (EIA 2017b). PTC data: (Sherlock 2015).



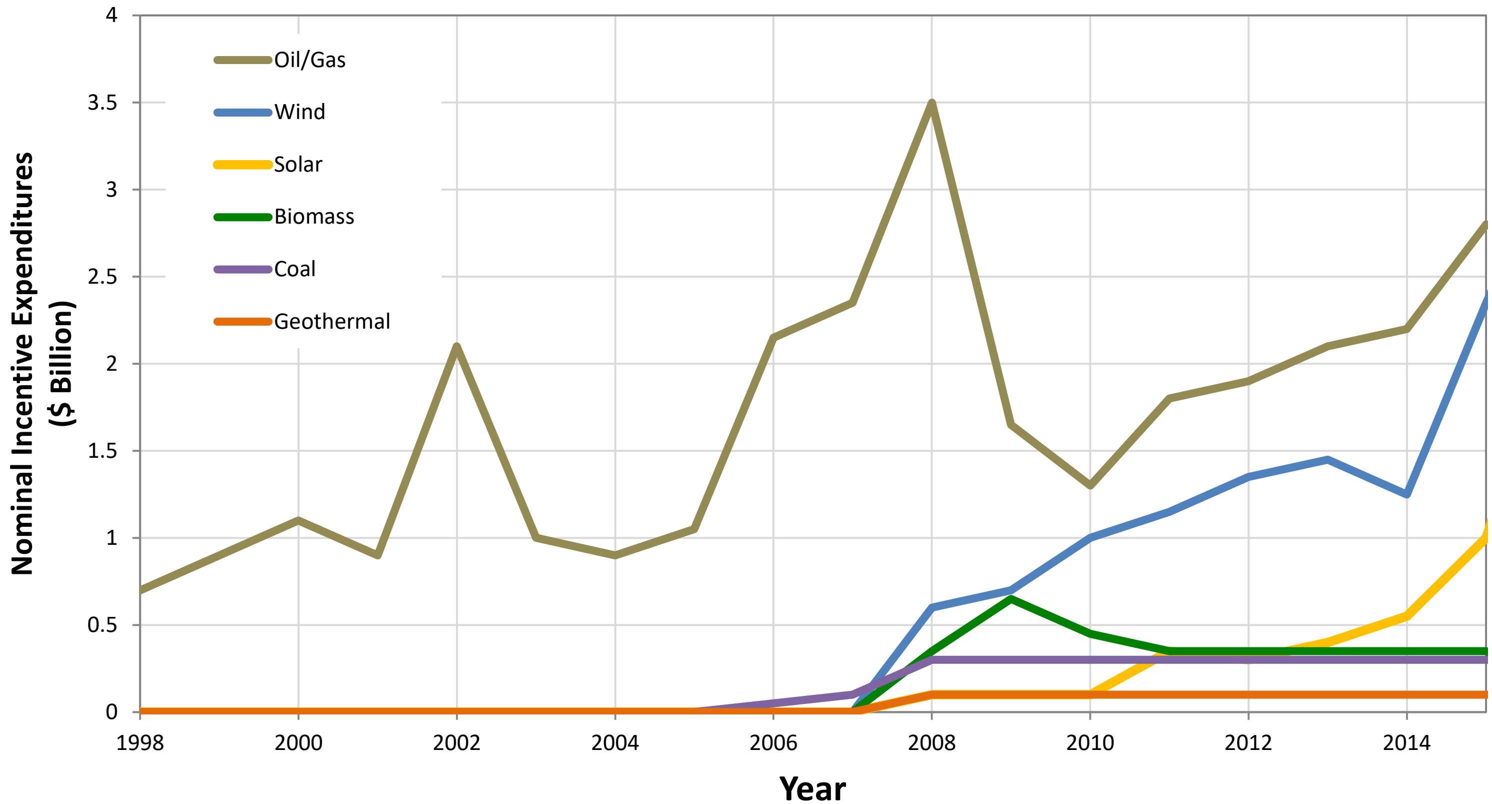
4.3.2 Market Sub-Attribute: Market Incentives

Impact of incentives on geothermal deployment. Geothermal capacity additions each year are shown in orange columns. The bar graph at the top shows when policies were enacted (diamonds) and the eligibility window (corresponding color bar). Both the Working Family and Tax Relief Act (red) and the Tax Increase Prevention Act of 2015 (pink) had retroactive eligibility windows. Of the six extensions, only one, the American Recovery and Reinvestment Act of 2009 provided certainty of the PTC for 5 years (through the end of 2013), the shortest timeframe for geothermal power development. This suggests that plants that were already planned and in the development process could have taken advantage of the PTCs, but new geothermal projects could not rely on the PTC being available when the plant went into production. Deployment data: (EIA 2017b). PTC data: (Sherlock 2015).

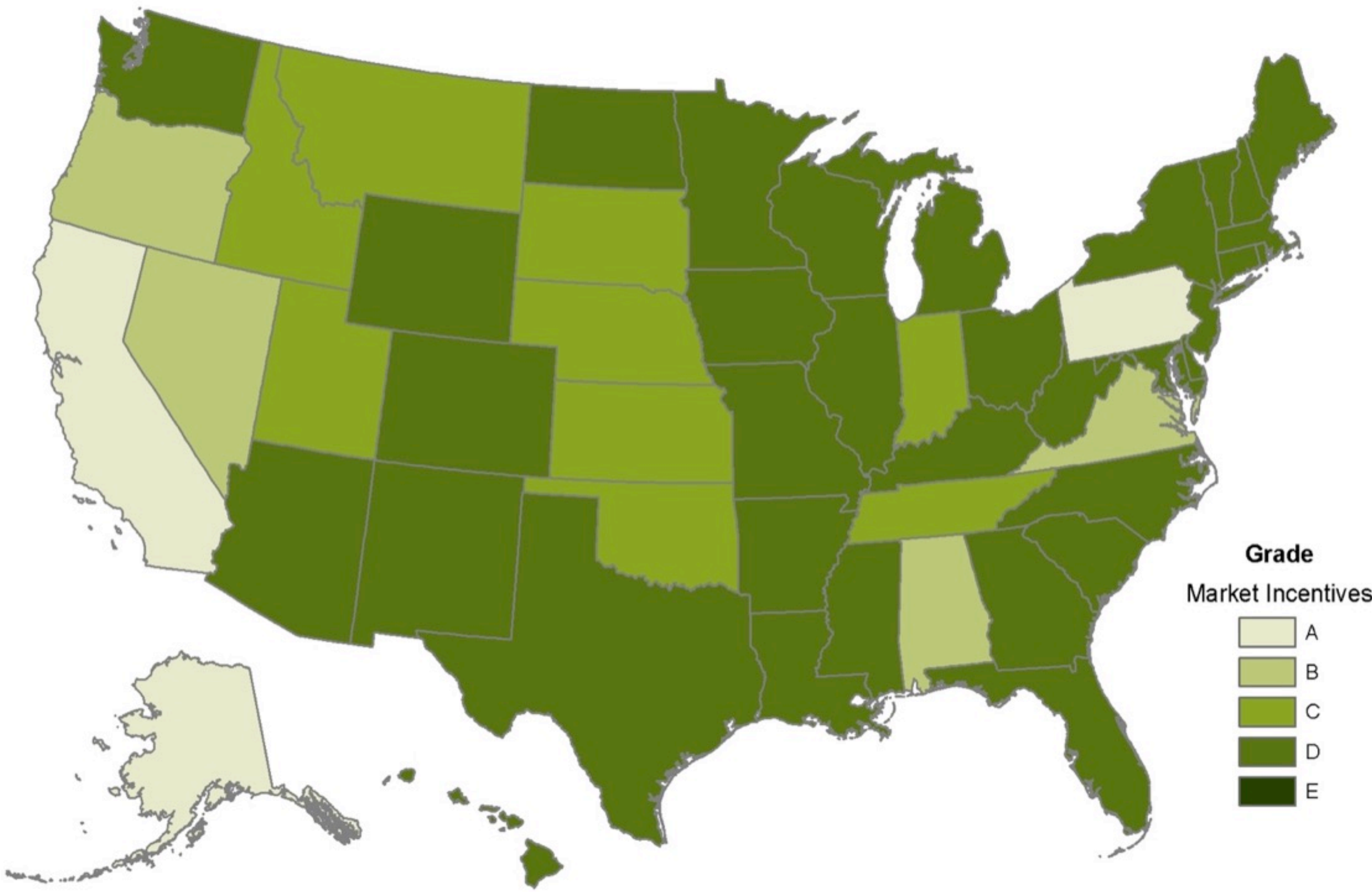


4.3.2 Market Sub-Attribute:
Market Incentives

Federal tax expenditures by energy projects. Wind, solar, biomass, coal, and geothermal were eligible for tax credits. The wind tax expenditures curve correlates with the data presented in Figure 8. With consistent tax credits starting in 2005, we see increasing tax expenditures for wind. The dip in 2014 in this curve reflects the expiration of the tax credit in 2014. Due to relatively long development timeframes and short extension windows of the tax credit, geothermal projects were not able to utilize the tax credit. Credits received by oil and gas are for exploration and development in early phases of project development and prove to be effective for this industry. This type of tax incentive may be a more effective tool for geothermal projects, as it would also help to reduce upfront exploration risk. (Data: Joint Committee on Taxation 2017; Department of the Treasury, 2017; Dinan 2017).



4.3.2 Market Sub-Attribute: Market Incentives



A	Qualifies for federal or state incentives that offset exploration costs and reduce project risk s(loan guarantees)
B	Qualifies for mix of both state and federal financial and tax incentives—includes grants, loans, and tax incentives
C	Qualifies for mix of both state and federal tax incentives (includes property tax)
D	Qualifies for either federal or state financial and tax incentives (not mixed); may require renewal of incentive
E	Does not qualify for state or federal incentives (no incentive available)

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.3.3 Market: Influence on Potential

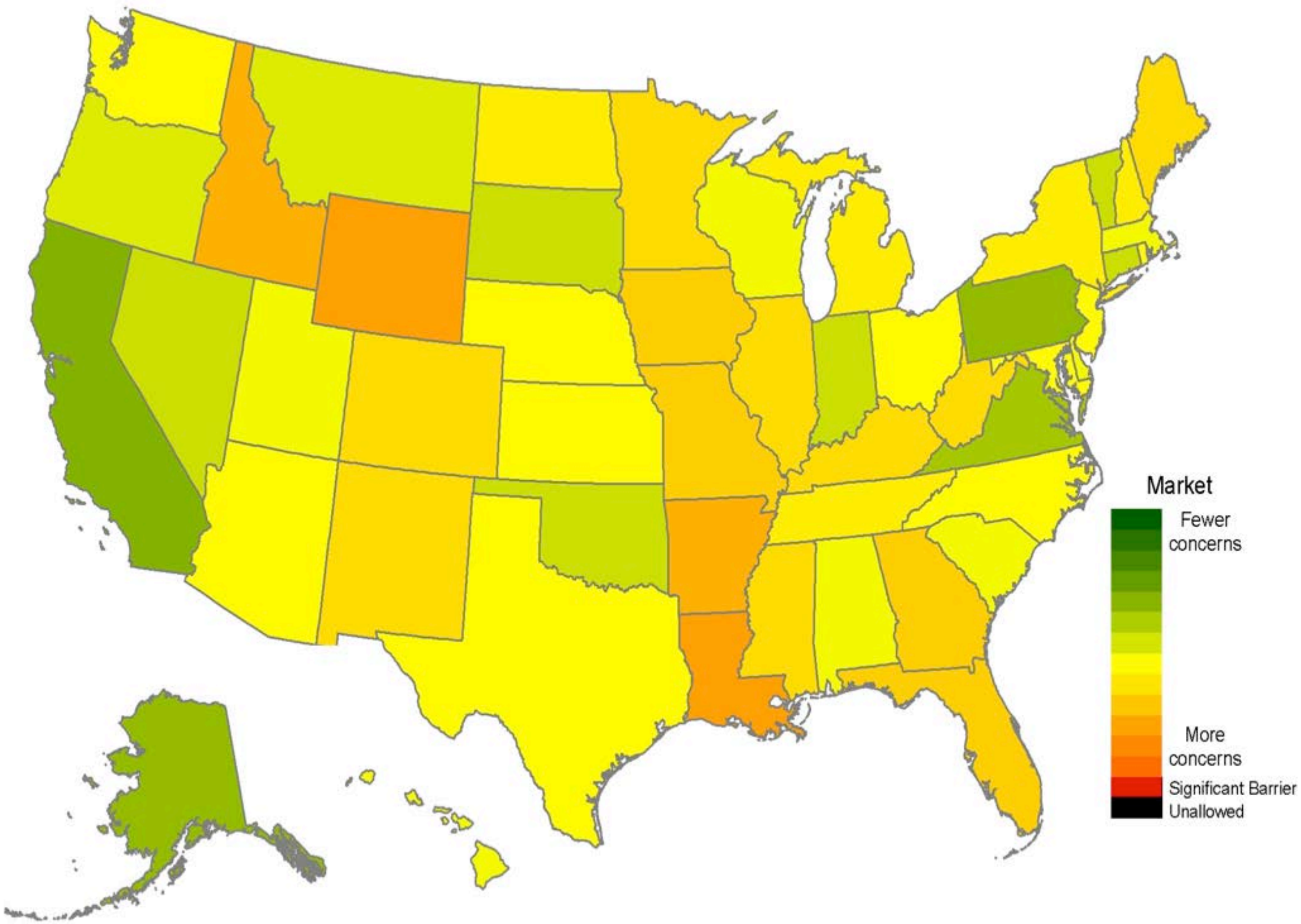
Sub-Attribute	Unallowed Grade(s)	Significant Barrier Grade(s)	Flagged Grade(s)
Market Demand	--	--	**D, E**
Wholesale Electricity Price	--	--	--
Policies	--	--	--
Incentives	--	--	--

Note: **Bolded** grades indicate data were available for mapping this sub-attribute. *Italicized* grades indicate that no data were available for mapping.

- None of the market conditions were considered to be unallowed or to have significant barriers.
- The D and E market demand grades would raise flags, but developers can sell to markets other than those in which the project is developed.

4.3.3 Market: Influence on Potential

Summary map of all four market sub-attributes



- The market summary map shows that some states (e.g., California, Nevada) are more attractive than others (e.g., Idaho, Wyoming) for geothermal sales.
- This does not restrict development in less attractive states because power can (and often is) developed in one state and shipped to an end user in another state.
- States in the East with favorable market conditions (e.g., Pennsylvania, Virginia) are near areas that have recently been investigated for EGS development (e.g., Cornell University et al. 2015)

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.3.4 Market Scenarios

Scenario	Description – Bottoms-Up Story	Inputs – How is this Modeled in ReEDS and dGeo?
BAU	• Electricity technologies (including renewables) that are competitive in current market conditions (with current policies/incentives) can be deployed.	• No change from way ReEDS is currently being run ○ No Clean Power Plan (CPP) ○ ReEDS represents current state RPSs
SCENARIO 1: RENEWABLES	• High renewable penetration	• Modeled with high state RPSs (average 49% throughout the United States) from previously published study (Mai et al. 2016).
SCENARIO 2: BASELOAD *(Diversification of portfolio; risk reduction)*	• Geothermal selected to provide grid stability: ○ GeoPower reduces cost of operating systems with VREs.	Run scenario three different ways: • FEDERAL: Baseload-only tax credit • STATE: RPS baseload set-aside • UTILITY: Transmission charge for VREs
SCENARIO 3: GEOTHERMAL *(local benefits)*	• Technologies are chosen based on benefits: ○ Geo power plants provide benefits to state and local communities (jobs, tax revenue, royalties)	Run two scenarios: • FEDERAL: Geothermal-only ITC/PTC extension • STATE: Geothermal power RPS set-aside/mandate
SCENARIO 4: MARKET VARIATION IN FUEL PRICE	• High natural gas prices	• High natural gas price case

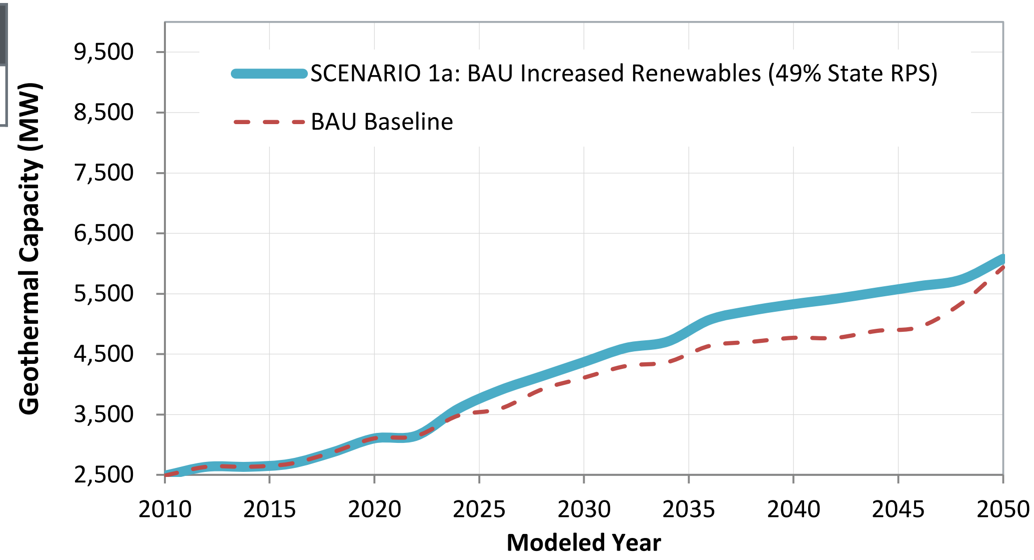
4.3.4 Market Scenario:
Scenario 1: Increased Renewables

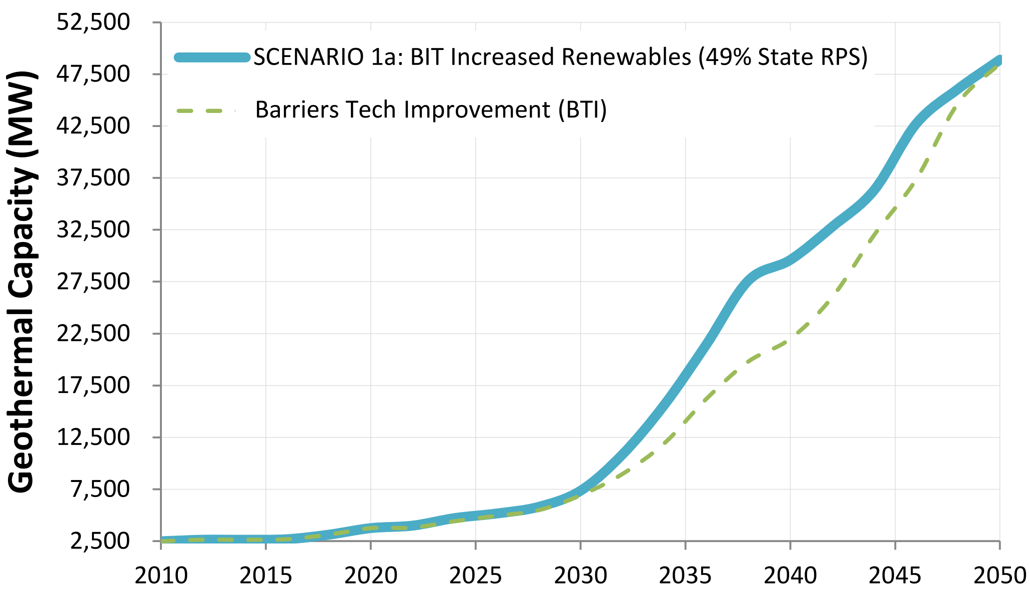
- A 2016 NREL report (Mai et al. 2016) examines a future scenario where RPSs are expanded, which assumes that nearly all states adopt an RPS with relatively aggressive targets. In the BAU scenario, renewables (including hydro) reach 26% of total U.S. electricity generation by 2030 and 40% by 2050. Under the High RE scenario, renewables reach 35% by 2030 and 49% by 2050.
- The analysis examines changes in electric system costs and retail electricity prices, which include all fixed and operating costs, including capital costs for all renewable, non-renewable, and supporting (e.g., transmission and storage) electric sector infrastructure; fossil fuel, uranium, and biomass fuel costs; and plant operations and maintenance expenditures. This scenario is included here but with updated geothermal data to look more specifically at the impact to geothermal deployment. The model shows limited increase in geothermal deployment relative to the baseline case, with the increase in renewables coming instead from utility-scale and distributed PV.

4.3.4 Market Scenario:
Scenario 1: Increased Renewables

Improvement	over BAU	Over BTI
1a: Increase RPS	150 MW (2%)	370 MW (1%)

- Modeled as a 49% RPS implemented throughout the United States.
- Increased RPS has minimal impact on 2050 deployment, though geothermal does deploy earlier in both the BAU improvement and BTI improvement scenarios.
- Deployment to meet the increased RPS likely comes from other renewables throughout the eastern United States.



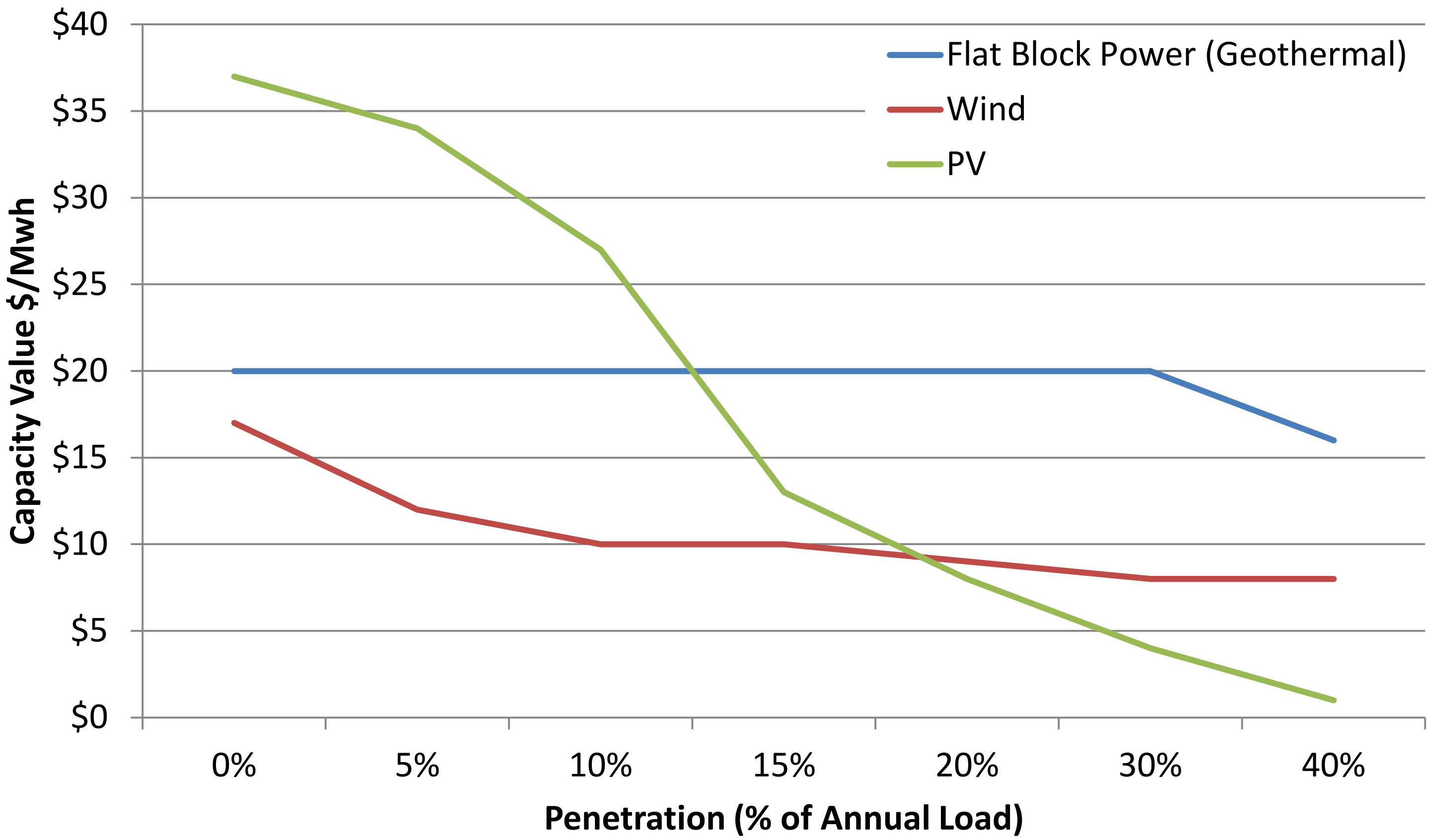


4.3.4 Market Scenario:
Scenario 2: Increased Baseload

States such as California and Arizona have been recognizing that the MWh-based approach used by traditional RPS policies does not differentiate between each renewable MWh based on its value to the grid or for reducing fuel consumption. These states are experiencing challenges as renewable energy production during certain times is beginning to provide diminished value in terms of reduced fuel consumption or capacity contribution (e.g., Denholm et al. 2015 and Figure 19). Both states have discussed using Clean Peak Standards, which build upon the RPS construct by adding a requirement that a certain percent of energy delivered to customers during peak load hours must be derived from clean energy sources (California AB1045; Huber and Burgess 2016).

4.3.4 Market Scenario:
Scenario 2: Increased Baseload

Marginal economic value of geothermal. Flat Block Power (Geothermal) delivers a constant amount of electricity on a 24x7 basis. Marginal value is calculated as the sum of capacity value, energy value, day-ahead forecast error, and ancillary services (Mills and Wiser 2012). For more information, see Young et al. (2017).



4.3.4 Market Scenario:
Scenario 2: Increased Baseload

Three scenarios were run to model increased benefits for baseload renewables:

2a. Federal-led baseload benefits: A 30% tax credit for baseload renewables only. Wind and solar projects have been eligible for a 30% tax credit for the PTC and ITC, respectively (see 26 USC § 48 and Consolidated Appropriations Act of 2016). Phase-outs for current PTCs and ITCs for wind and solar remain as planned. This scenario analyzes the potential impact of extending the ITC at 30% through 2050 for geothermal and other renewable energy baseload technologies that have yet to reach significant deployment as a mechanism for diversifying the renewable energy generation portfolio.

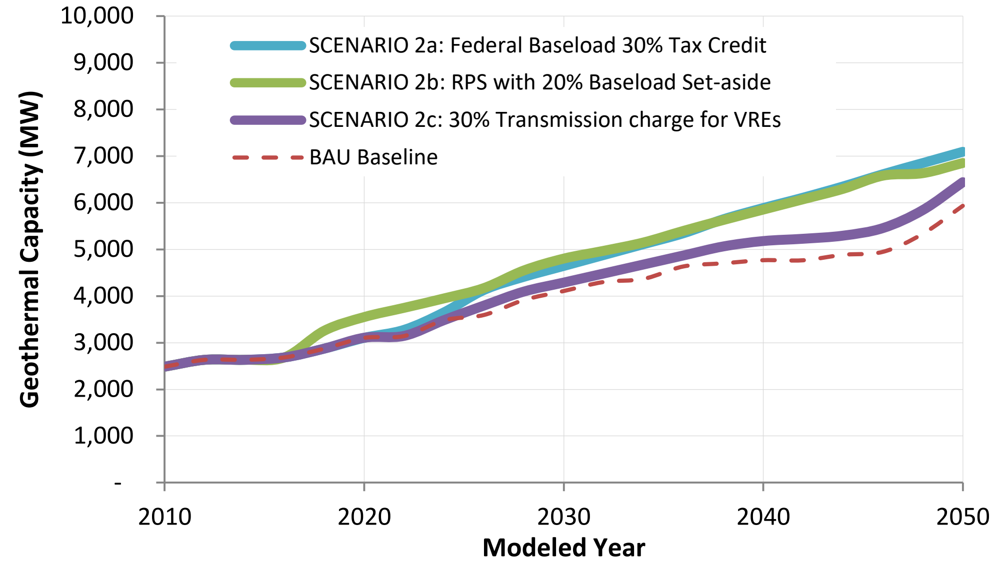
2b. State-led baseload benefits: A 20% set-aside for baseload renewables in current projected state RPS levels. Recent legislation in California proposed that 20% of remaining RPSs be filled with baseload renewables.

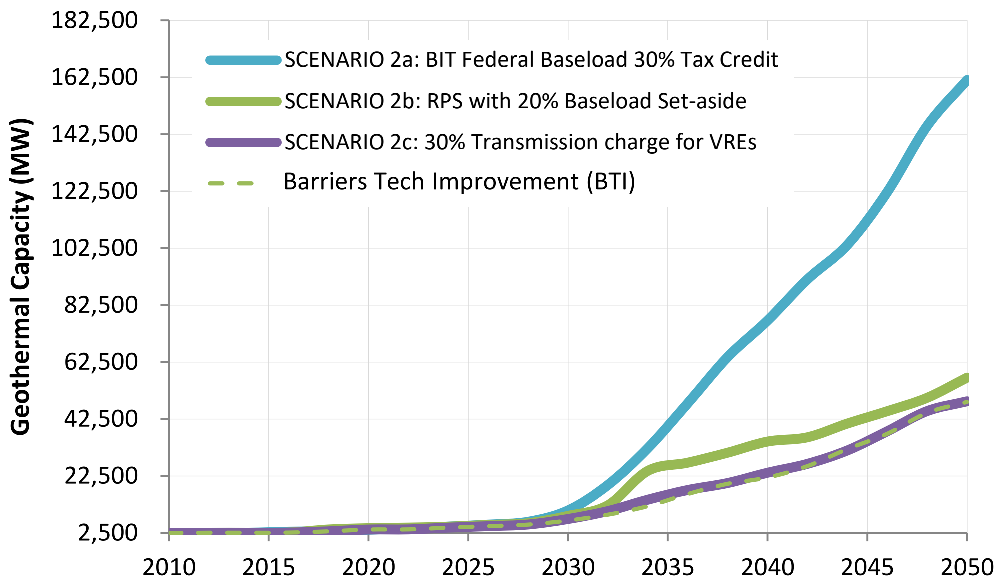
2c. Utility-led baseload benefits: A 30% increase in transmission charge (not total project costs) for variable renewables using current projected state RPS levels. Though there are no bills that we are aware of that directly support a 30% increase in transmission charges, there are laws and regulations that require utilities to procure energy storage. Adding energy storage to a variable renewable project can increase total project costs by 33% or more (Bade and Maloney 2017).

4.3.4 Market Scenario:
Scenario 2: Increased Baseload – Set-Aside

Improvement	over BAU	over BTI
2a: Baseload Tax Credit	1.15GW (19%)	50 GW (103%)
2b: Baseload Set-Aside	920 MW (15%)	93 GW (192%)
2c: VRE Transmission Charge	500 MW (8%)	280 MW (1%)

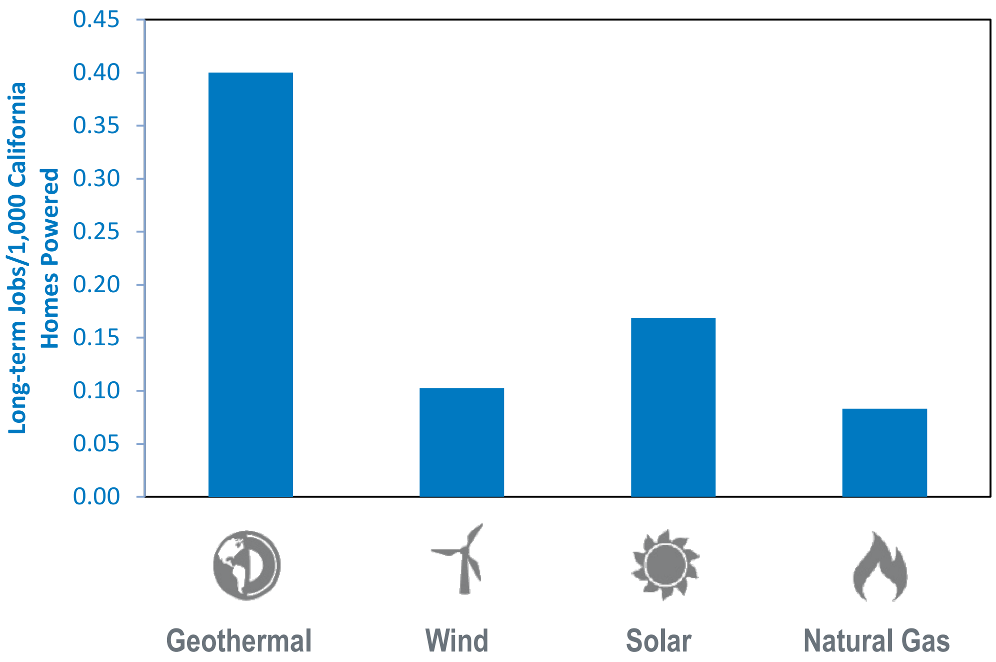
- The 20% baseload set-aside scenario (with BAU assumptions) predominantly builds CSP to satisfy the baseload set-aside, with smaller, relatively equal amounts of geothermal, hydropower, and biomass plants.
- When combined with improved technology, a VRE transmission charge has little impact, a 20% baseload set-aside increased geothermal deployment by 8.5 GW (8%), and a 30% federal baseload tax credit increased geothermal deployment by 113 GW (233%) in the model.





4.3.4 Market Scenario:
Scenario 3: Increased Geothermal

Rationales for a geothermal set-aside include diversification of renewable energy resources to support grid services and system reliability (discussed previously) and state and local economic benefits. Recent analysis (Young et al. 2017) looked at long-term local benefits to various energy projects. The project-specific impact can vary by project and location within a state. Nevertheless, the results of this analysis can offer some perspective regarding the relative impact of certain projects based upon technology. The results of this analysis suggest that geothermal offers the most long-term jobs (bar graph below) and provides more local operations and maintenance (O&M) spending than other technologies analyzed (bar graph, next slide).

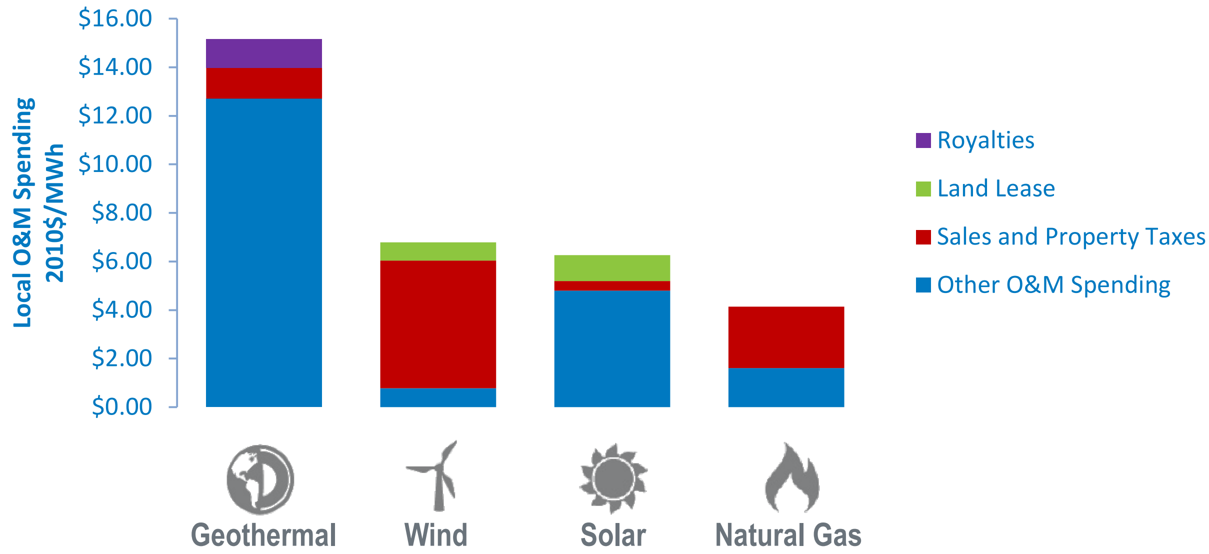


Comparison of local O&M spending per 1,000 homes powered by certain generation sources. Data vary geographically and are shown for California plants (data from NREL JEDI analyses for Young et al. 2017b).

4.3.4 Market Scenario:
Scenario 3: Increased Geothermal

Royalties

- Geothermal uses federal resource; 75% (reflected in graph) goes to state and local government. Geothermal on state or private land would likely generate equal or greater royalties.
- Natural gas fuel royalties are generated out of state.
- This analysis assumes wind and solar do not generate royalties (although they may pay other fees for access and use).



Land Lease

- Geothermal is assumed to be located on federal land; no lease fees are paid once production begins.
- Wind is assumed to be located on leased private land.
- Solar is assumed to be located on leased private land (BLM lease structure is assumed).
- Natural gas is assumed to be located on purchased land.

Sales & Property Taxes

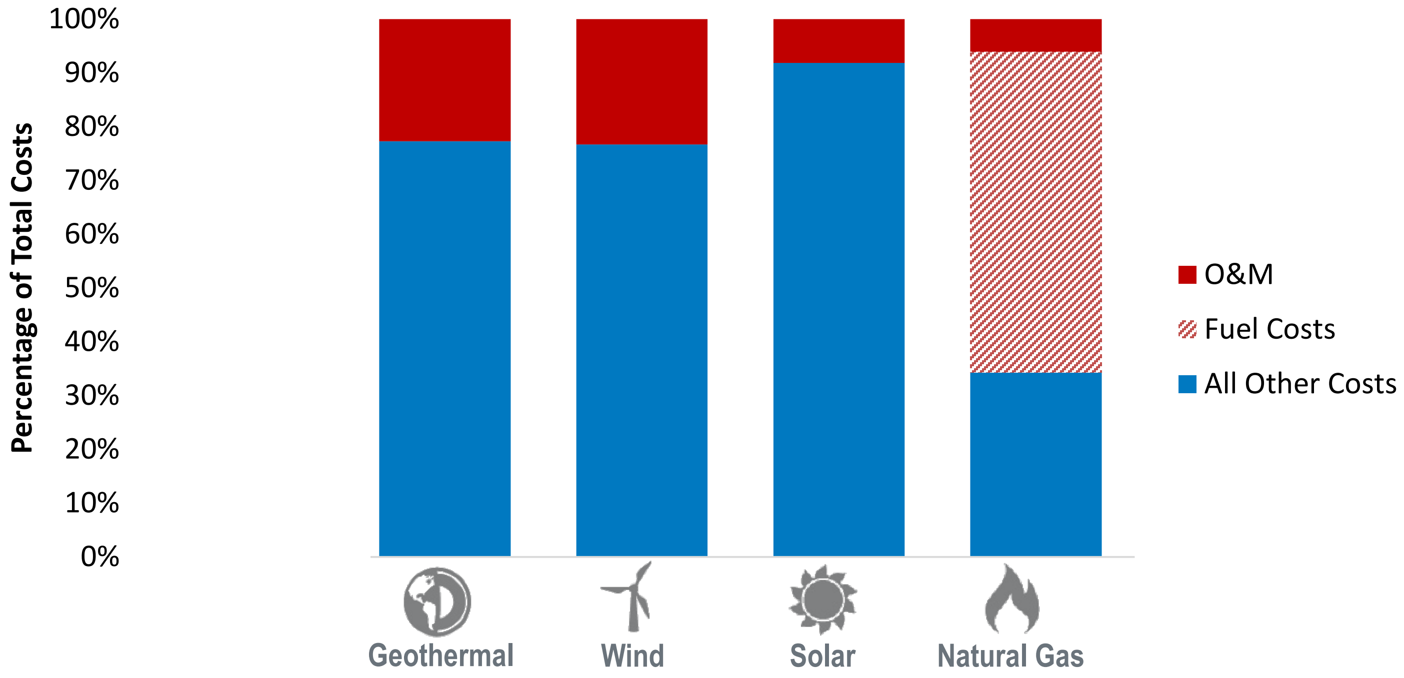
- All projects pay sales taxes.
- Geothermal and wind property taxes were based on industry estimates.
- Solar is exempt from California property taxes.
- Natural gas property taxes were based on California assessor methodology.

Other O&M Spending

- 100% of geothermal spending is local (based on industry input).
- 16% of wind spending is local (JEDI assumption).
- 100% of solar spending is local (JEDI assumption).
- 5% of natural gas spending is local (JEDI assumption).

4.3.4 Market Scenario:
Scenario 3: Increased Geothermal

Comparison of O&M spending by technology as a percentage of LCOE. The high percentage of O&M spending on geothermal plants means increased local economic benefits for communities in which geothermal is developed. Fuel for natural gas is called out separately because it is not considered to be sourced locally and is not included in the bar graph on the previous slide.



4.3.4 Market Scenario:
Scenario 3: Increased Geothermal

Policymakers interested in leveraging possible geothermal benefits in relation to other technologies could consider policy prescriptions that boost geothermal development, including favorable tax credits or technology set-asides. Two scenarios were run to model the impact of favorable policy on geothermal deployment:

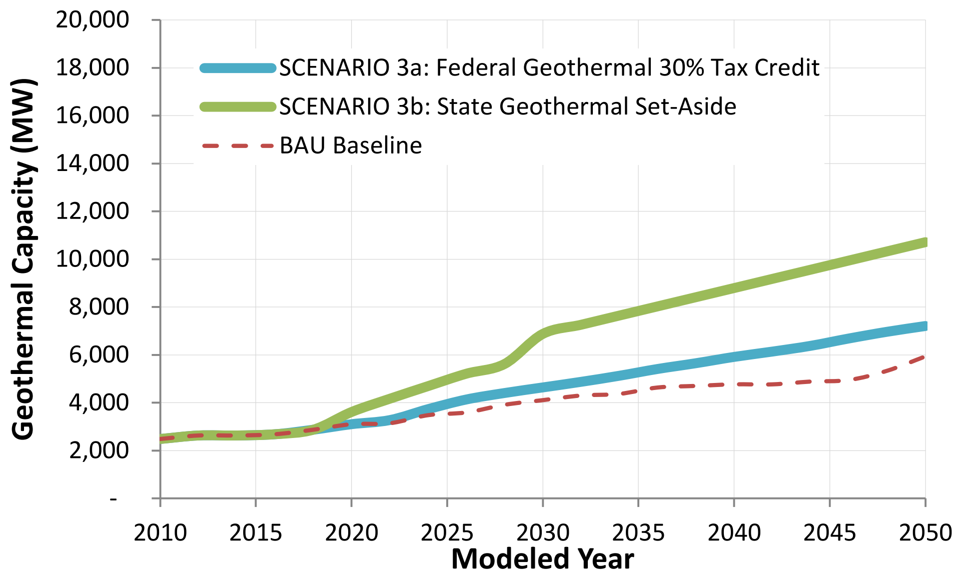
3a. Federal-led geothermal benefits: A 30% tax credit for geothermal, a level equal to current solar ITC (*see* 26 USC § 48 and Consolidated Appropriations Act of 2016). Phase-outs for current ITCs for wind and solar remain as planned. As discussed, incentives including the federal ITC and PTC are helpful in making renewable energy projects financially viable. The ITC is currently at 10% for geothermal and is being reduced to 10% for solar projects not commencing construction by 2022 (26 USC § 48). This improvement scenario analyzes the potential impact of extending the ITC at 30% through 2050 for geothermal as a mechanism for diversifying the renewable energy generation portfolio and increasing local jobs and spending.

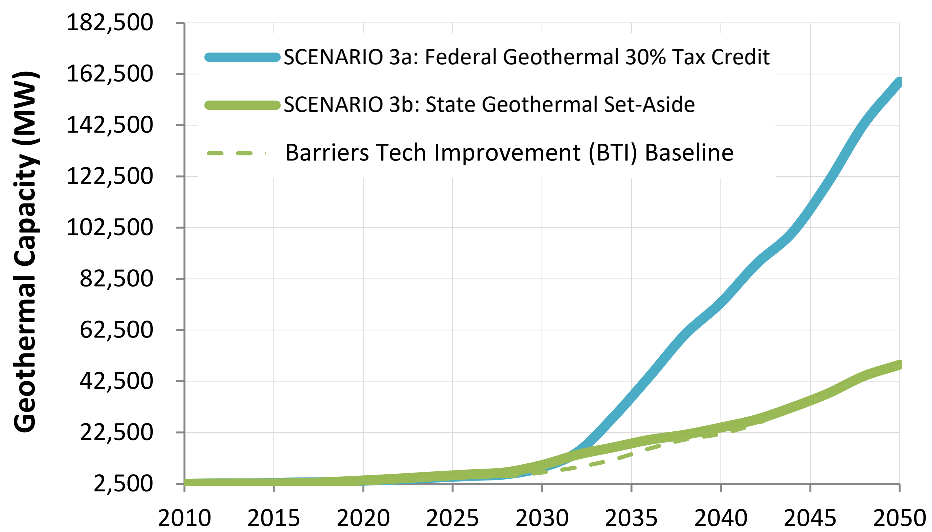
3b. State-led geothermal benefits: A set-aside for geothermal power. A set-aside for geothermal development has previously been proposed in the California State Legislature; in 2013-2014, California Senator Ben Hueso (D) proposed SB-1139, a bill that would have created a 500-MW set-aside for geothermal development by the end of 2024 (SB-1139). SB-1139 would have required each “retail seller” to procure a proportionate share of the 500 MW based on the forecast retail sales for 2018 as determined by the California Public Utilities Commission (SB-1139). SB-1139 also included a provision preventing the California Public Utilities Commission from approving any PPA that would have resulted in a cumulative increase in the average rate of retail electricity by 1% or more (SB-1139). SB-1139 was passed in the California State Senate but ultimately failed to receive the necessary votes to pass the California General Assembly (SB-1139).

4.3.4 Market Scenario:
Scenario 3: Increased Geothermal – Set-Aside

Improvement	over BAU	over BTI
3a: Tax Credit	1.3 GW (21%)	111 GW (229%)
3b: Set-Aside	4.8 GW (80%)	400 MW (1%)

- Similar to the effect of solar set-asides (slide 73), a geothermal set-aside is more effective under the BAU scenario than in IT scenario when lower costs allow geothermal to better compete in the market.
- Similar to cost-competitive wind receiving a tax credit (slide 76), the tax credit is incredibly impactful in deploying geothermal under BTI scenarios.
- Note deployment takes off in 2032, after expiration of solar/wind tax credits and EGS becomes available.
- As discussed, tax credits more akin to oil/gas (though not modeled) are likely to be even more impactful as it helps to lower upfront risk.





4.3.4 Market Scenario:
Scenario 4: Changes in Market Conditions

Predicting future market conditions is not an exact science. Therefore, several scenarios were run with varying future market conditions to understand the impact it may have on geothermal deployment.

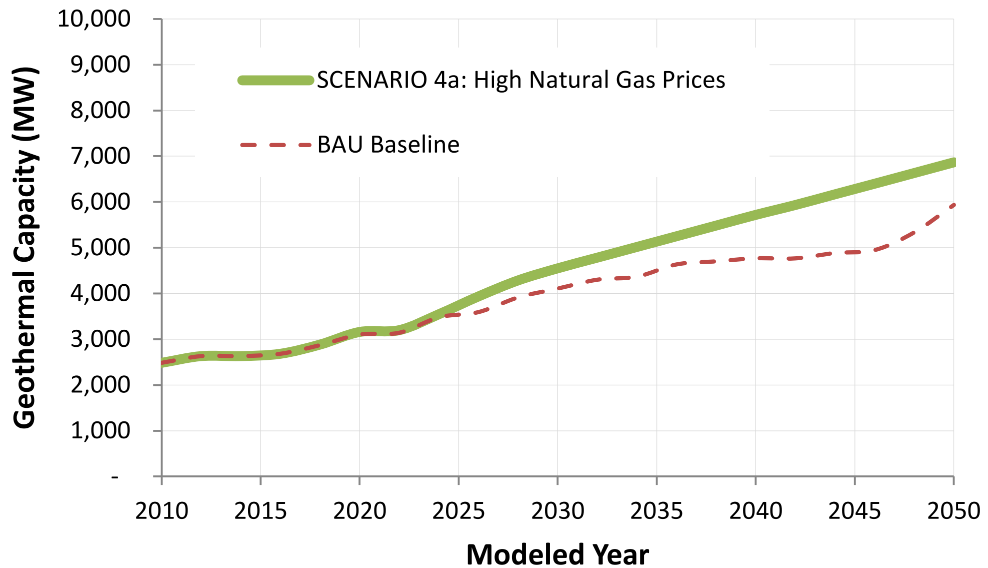
4. High gas prices. 2016 NREL Annual Technology Baseline (ATB) data on long-term prices of natural gas shows the potential for relatively little change in natural gas prices between 2016 and 2040 in a low natural gas price scenario, with natural gas prices rising approximately 2% by 2040 (NREL 2016). The mid-case natural gas price scenario shows an expected rise from $3.31/MMBTU in 2016 to $5.45/MMBTU by 2040, a roughly 65% increase in natural gas prices. However, if natural gas prices rise over this period of time from the low-case scenario of $3.28/MMBTU by 2040 to a high-case natural gas price of $9.40/MMBTU by 2040, natural gas prices could see close to a 300% increase over the next 25 years.

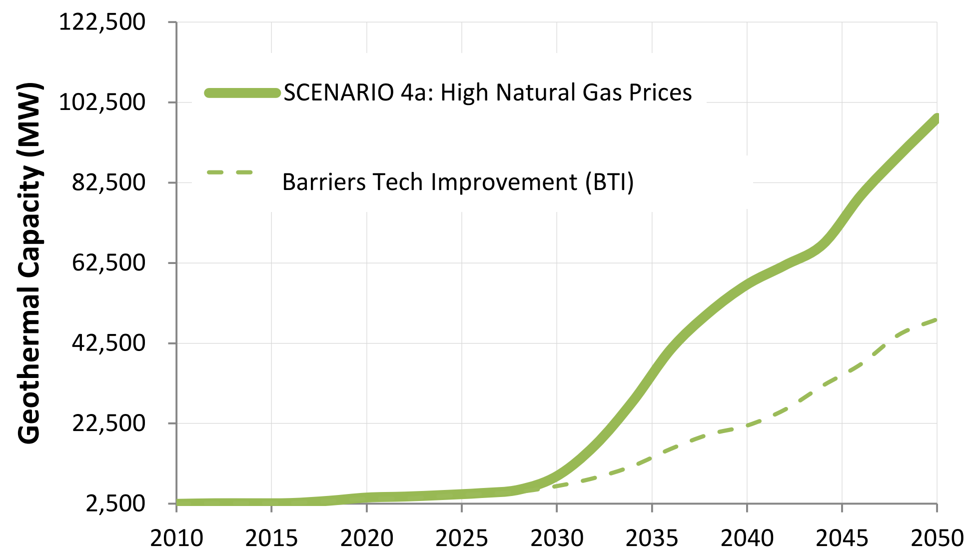
Using the 2040 mid-case natural gas price as a baseline, this could change the LCOE for natural gas combined cycle power plants running at average capacity (48%) from $66/MWh by 2040 in the mid-case scenario to $91/MWh in the high-case scenario and combined cycle power plants running at high capacity (87%) from $54/MWh in the mid-case scenario to $79/MWh in the high-case scenario. Geothermal power does not require a fuel source and, as such, could be viewed as a hedge against rising natural gas prices. This scenario discusses the impact that high natural gas prices could have on geothermal deployment by 2030 and 2050.

4.3.4 Market Scenario:
Scenario 4: Changes in Market Conditions

Improvement	over BAU	over BTI
4a: High Nat Gas	930 MW (16%)	50 GW (103%)

- Market conditions, such as an increase in natural gas prices or increase in electrification, can have a noticeable impact on geothermal deployment.
- The modeling suggests that the lower the cost of geothermal, the larger the impact of market scenarios.
- These models suggest that geothermal can be used to hedge against high natural gas prices in the future.





4.4.1 Barrier Overview: Transmission

We identified three sub-attributes that most significantly contributed to the ability to access transmission:

- Distance to the nearest transmission line
- Interconnection costs (including upgrade costs)
- Transmission (or "wheeling") costs.

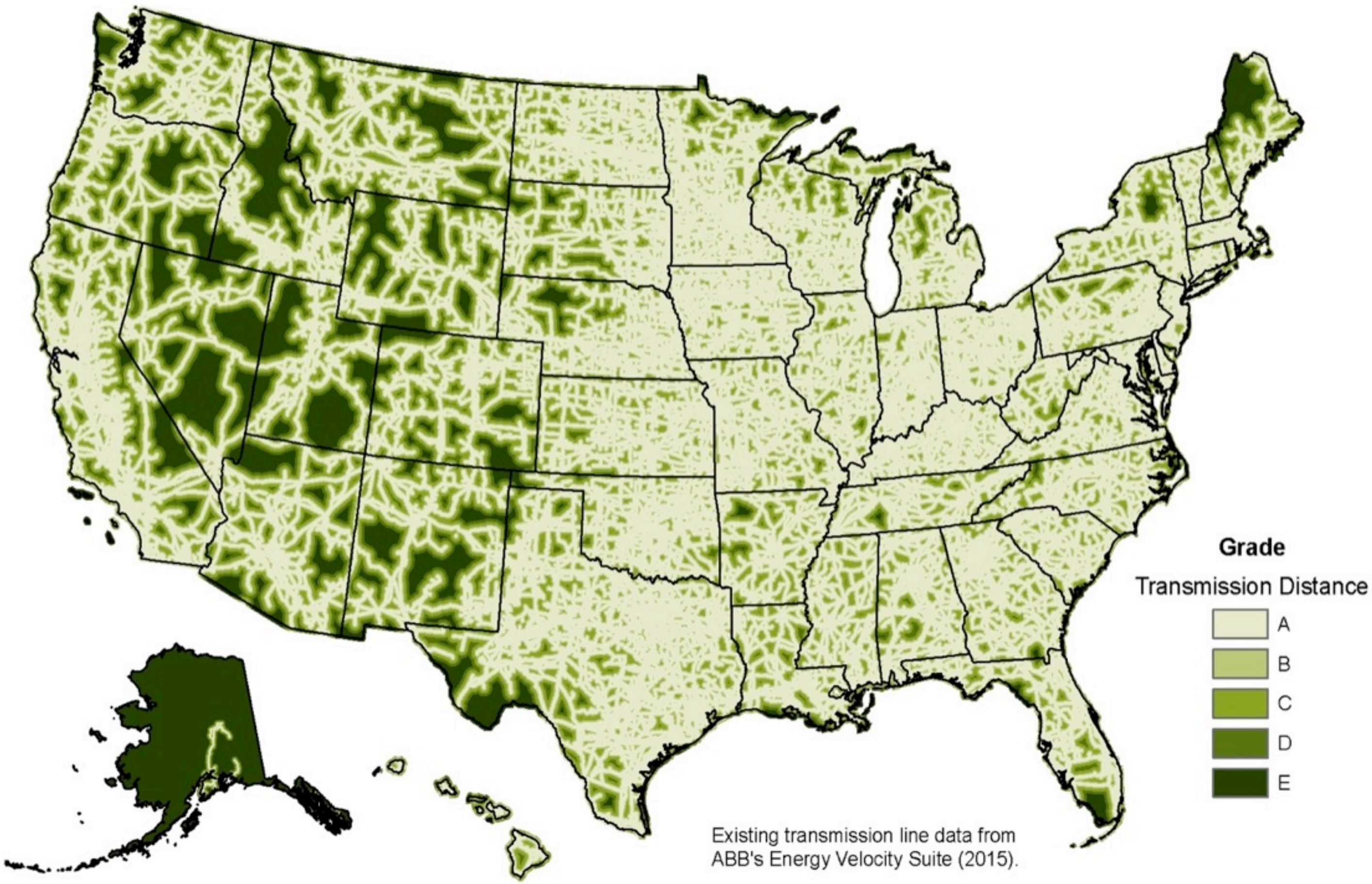
4.4.2 Transmission Sub-Attribute: Distance to Nearest Transmission Line

Distance to the nearest transmission line is an important consideration to determine the cost of permitting and constructing a generation tie-line to connect the geothermal power plant to the grid.

Developers interviewed for the Institutional Barrier Task Force Report suggested a rule of thumb of one-mile-per-megawatt to determine the economic feasibility of developing a geothermal power plant and connecting it to the grid.

For the Institutional Barrier Task Force Report, we applied a default plant size of 20 MW to map geothermal resources to existing transmission infrastructure. The methodology would require further evaluation for projects larger than 20 MW.

4.4.2 Transmission Sub-Attribute:
Distance to Nearest Transmission Line



	Distance to Nearest Line:
A	<5 km
B	5 - 10 km
C	10 - 20 km
D	20 - 30 km
E	>30 km

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.4.2 Transmission Sub-Attribute: Interconnection Costs

Interconnection costs are upfront costs paid by the developer to connect the geothermal power plant to the grid.

Interconnection costs include:

- Engineering costs ($10k-$20k): For developer engineering drawings to submit with an interconnection request to the utility
- Feasibility and grid connection study costs ($50k-$150k): For utility to conduct feasibility and grid connection analysis (paid by developer)
- Interconnection costs: Cost to connect to the grid, including transmission system and distribution network upgrade costs.

4.4.2 Transmission Sub-Attribute: Interconnection Costs

Note: Grades are not mappable – project dependent

Table 1. *Interconnection Cost Grades*

A	No interconnection system costs (plus engineering cost and feasibility costs)	
B	Minor transmission system costs (gets paid back) - $2-3M (plus engineering and feasibility costs)	
C	Significant transmission system costs (gets paid back) OR distribution network costs (do not get paid back) - up to $1M/MW (plus engineering and feasibility costs)	Flag
D	Significant transmission system costs (gets paid back) OR distribution network costs (do not get paid back) - greater than $1M/MW (plus engineering and feasibility costs)	Significant Barrier
E	Utility says interconnection is not possible	Unallowed

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.4.2 Transmission Sub-Attribute: Transmission Costs

Transmission costs (also referred to as transmission tariffs) are operational costs to transmit electricity from the point of interconnection to the power purchaser. Transmission costs do not apply if the point of interconnection is to the power purchaser's grid.

However, if the electricity must be transmitted over another utility's grid to the power purchaser, the operator must pay the utility to "wheel" the electricity across its grid to reach the power purchaser.

Typical transmission wheeling costs provided by geothermal developers interviewed by the Institutional Barrier Task Force ranged from $4/MWh (Bonneville Power Administration) to $10-$12/MWh (CA Independent System Operator).

For a 20-MW geothermal power plant, an operator would pay between $700k and $2M per year in transmission costs.

4.4.2 Transmission Sub-Attribute: Transmission Costs

Note: Grades are not mappable – project dependent

Table 1. *Transmission Cost Grades*

A	Customer is inside your utility PPA - transmission cost = $0	
B	*Single wheel* - utility takes power into system and sells out of system (see prices above - $4-12/MWh - for examples given)	
C	*Two wheels ($4-12/MWh/wheel)* OR Single wheel + system upgrade (path full), so one-time $50M transformer upgrade PLUS transmission costs ($4-12/MWh)	
D	*Three wheels ($4-12/MWh/wheel)* OR Path does not exist, but transmission path proposed waiting for subscribers - developer can pay for subscription	Flag
E	*Four wheels ($4-12/MWh/wheel)* OR no path to sell power, so need to build path (billions of $)	Significant Barrier

All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

4.4.3 Transmission: Influence on Potential

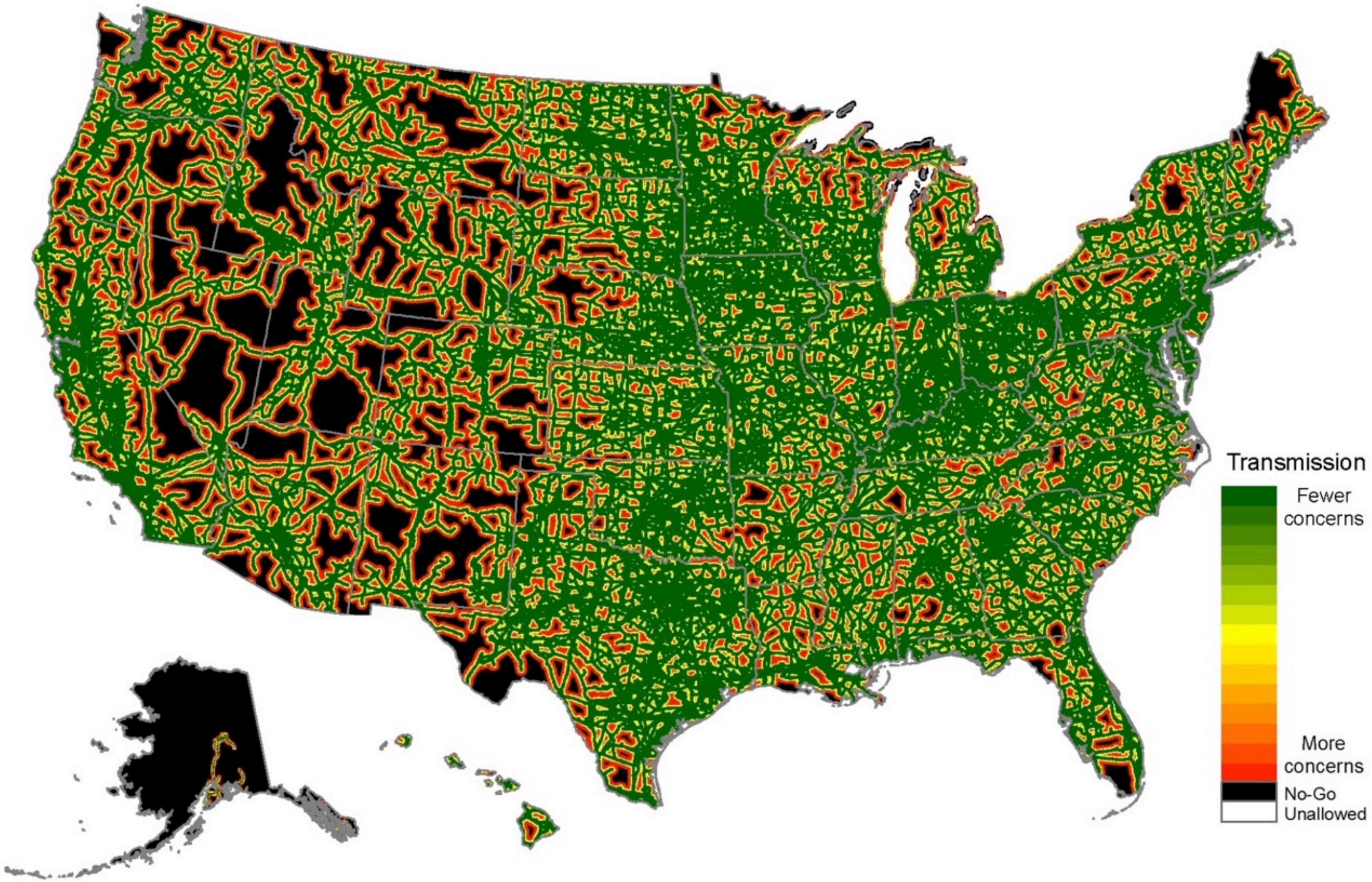
Attribute	Sub-Attribute	Unallowed Grade(s)	Significant Barrier Grade(s)	Flagged Grade(s)
Transmission	Distance to Transmission*	--	**D, E**	**C**
Transmission	Interconnection Cost	*E*	*D*	*C*
Transmission	Transmission Cost	--	*E*	*D*

*Dependent upon size of power plant; larger plants can handle larger distances, typically up to 1 mile/MW

Note: **Bolded** grades indicate data were available for mapping this sub-attribute. *Italicized* grades indicate that no data were available for mapping.

4.4.3 Transmission: Influence on Potential

Summary map of all three transmission sub-attributes

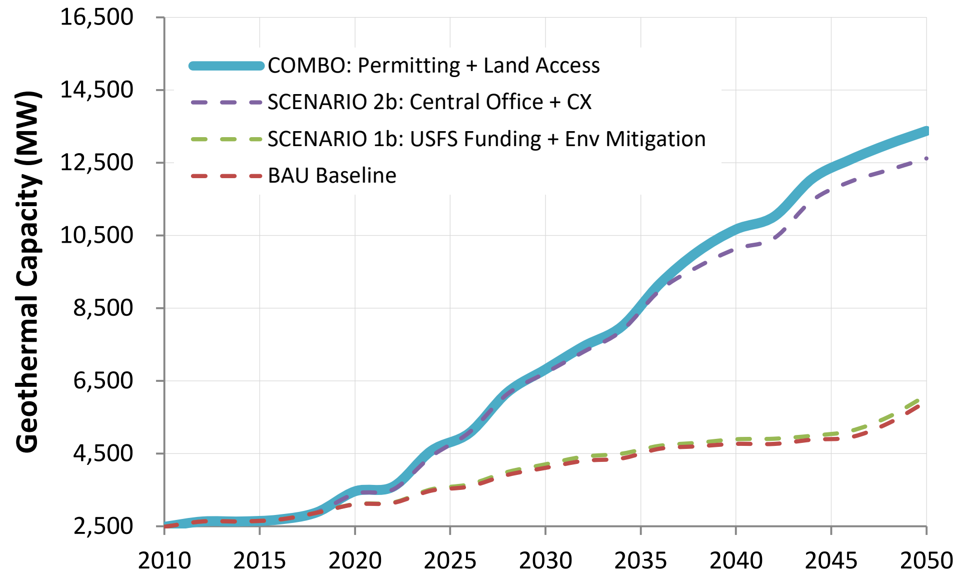


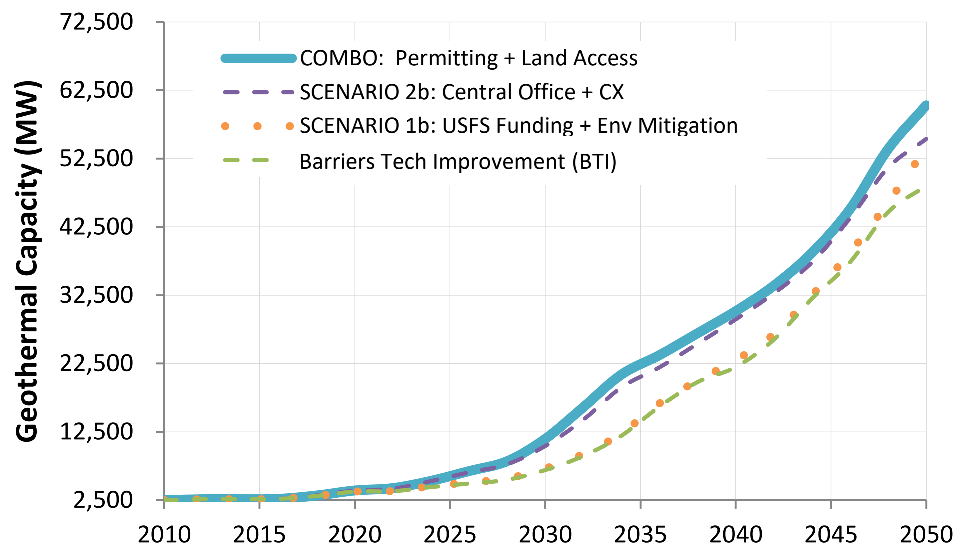
All maps are available interactively on GeoProspector: https://maps-stage.nrel.gov/georeport

5.1 Cumulative Barriers Analysis:
Combination Scenario Results

Combination	BAU	BTI
Permitting + Land Access	750 MW (17%) *Over permitting alone*	4.9 GW (10%) *Over permitting alone*

- Though increased land access had little impact on deployment alone, when combined with permitting, we see measured impact on deployment in both the BAU and BTI cases.

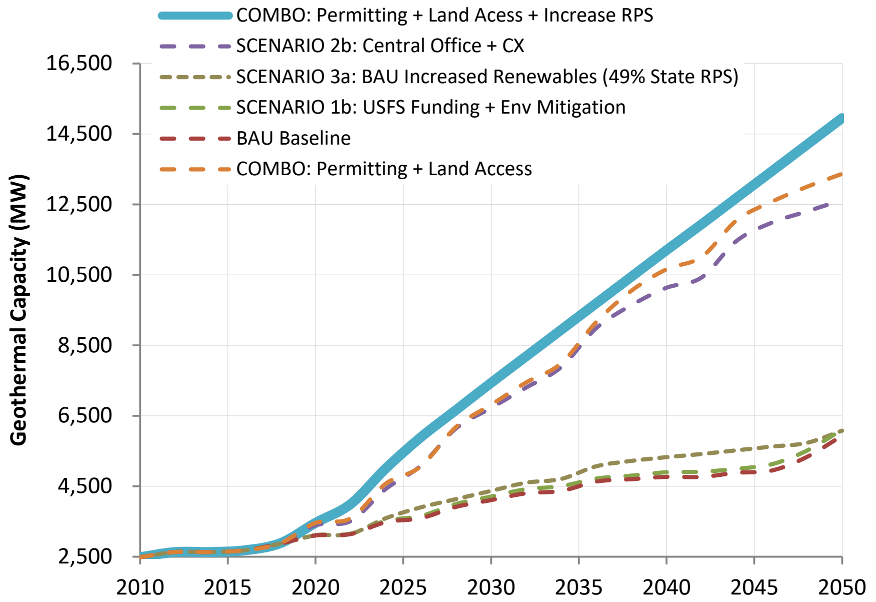


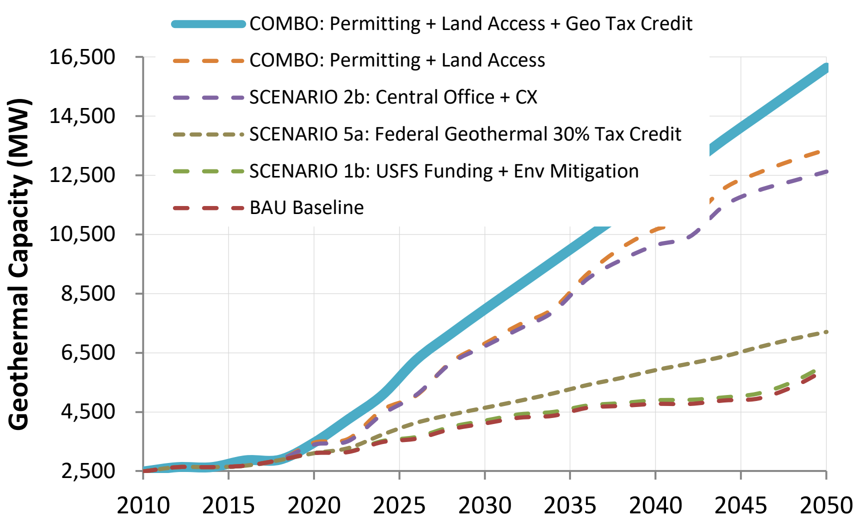


5.1 Cumulative Barriers Analysis: Combination Scenario Results

Improvement in BAU Case	Alone over BAU	Over Permitting and Land Access Improvements
Increase RPS	2%	27%
Geo Tax Credit	*21%*	*47%*
High Gas	*16%*	*37%*

- In fact, when we combine these improvements with other scenarios, the other scenarios have increased impact.
- For example:
  - The Increased Renewables scenario, which had little impact (2%) in the BAU case, now creates a 27% increase in deployment.
  - The Geothermal Tax Credit scenario, which had some impact (21%) in the BAU case, now has a 47% increase in deployment.
  - The High Gas scenario had 16% increase alone and now has a 37% increase.





6.1 Additional Barriers: Social Acceptance

Though not part of the original scope of this analysis, social acceptance of geothermal energy often poses a barrier toward geothermal energy development. Success in project development depends upon the attitude of affected stakeholders, including affected members of the public, policymakers, and market actors (Pellizzoni 2010; Reith et al. 2013). In fact, social acceptance influences some of the sub-attributes discussed above, such as the market sub-attributes policies and incentives and many of the land access sub-attributes. Therefore, we discuss it briefly in this section, with recommendations for further research in this area.

Wüstenhagen et al. (2007) state that many of the barriers for achieving successful renewable projects at the implementation level can be considered as a manifestation of lack of social acceptance. The Wüstenhagen et al. (2007) study defines social acceptance of renewable energy technologies as a combination of three categories: socio-political acceptance; market acceptance; and community acceptance.

6.1 Additional Barriers: Social Acceptance

Community acceptance describes the acceptance of specific projects at the local level, including potentially affected populations, key local stakeholders, and local authorities. This is the area where social debate around renewables arises and develops and the one that has attracted most of the social research traditionally carried out for geothermal energy (e.g., Pellizzone et al. 2015). Examples of challenges to community acceptance of geothermal include Glass Mountain (Dadigan 2016) and Maui, Hawai'i (Stickler 2013).

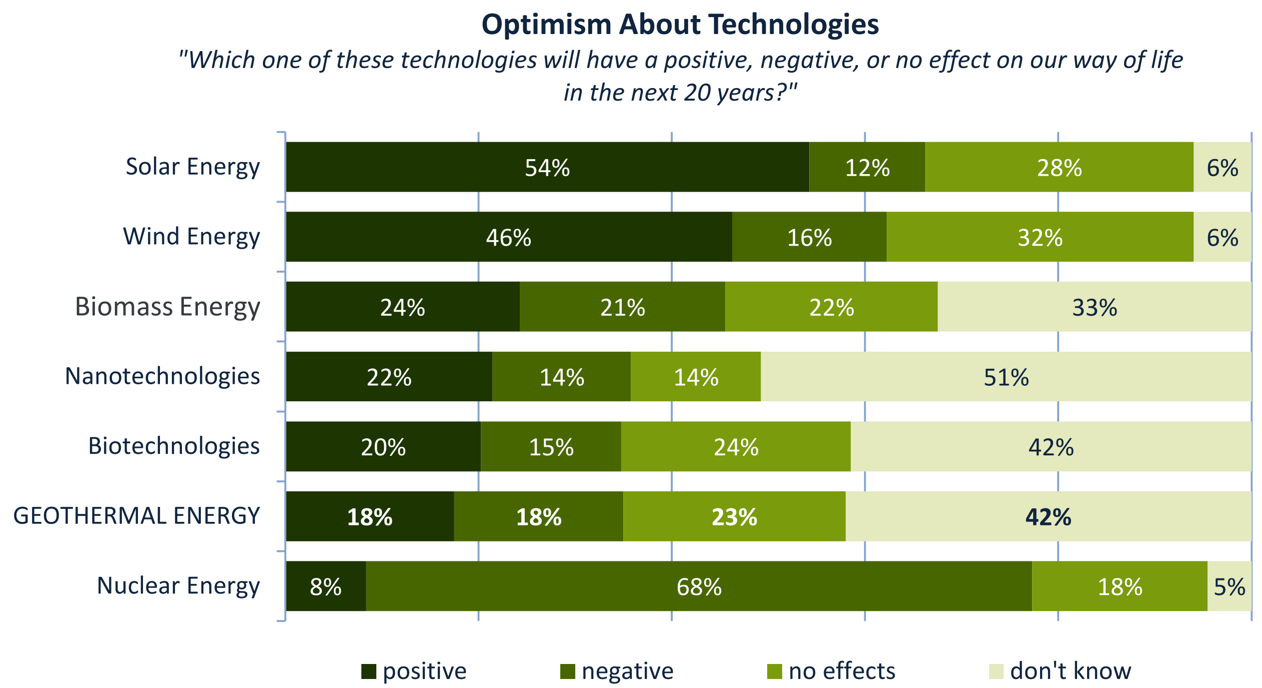
Market acceptance refers to the process by which market parties adopt and support (or do not support) the energy technology with things like green power marketing and willingness to pay for green power. Market acceptance includes power purchasers, consumers, and investors. Examples of challenges to market acceptance of geothermal include the difficulty (highlighted by experts in our study) in obtaining competitive PPAs, challenges to obtaining financing for geothermal projects (Speer and Young 2016), and developer-described lack of understanding by power purchasers and other market players of the value of the baseload benefits that geothermal can provide.

Socio-political acceptance describes the acceptance of both technologies and policies at the most general level, including levels of acceptance by the general public, key stakeholders, and policymakers. Stakeholders and policymakers involved in discussing renewable policies become crucial when addressing planning issues or promoting local involvement initiatives. Examples of challenges to socio-political acceptance of geothermal include the absence of "geothermal" when media and the public talk about renewables "like solar and wind" and special preferences given to solar and wind over geothermal in policies such as RPSs and the Clean Power Plan (as previously discussed).

Three categories of social acceptance (adapted from Wüstenhagen et al. 2007). Mass media plays a prominent role in shaping attitudes in all three categories (Pellizzoni 2010).

6.1 Additional Barriers: Social Acceptance

Social acceptance research for geothermal has taken place mostly internationally, such as in Europe (e.g., ENGINE 2007; Pellizzone et al. 2015; Reith et al. 2013; Leucht et al. 2010), Australia (Dowd et al. 2010; Romanach and Carr-Cornish 2013), Indonesia (Shoedarto et al. 2016), and Japan (Kubota 2015). Most of these papers focus only on community acceptance. For example, a recent study of social acceptance of geothermal energy in Italy (Pellizzone et al. 2015) showed that the public's awareness and optimism of geothermal was much less than that for solar and wind energy. Some papers also discuss mitigation measures for social acceptance barriers, such as Batak and Dugan's (2015) discussion of community impact reviews. Other renewable technologies, however, such as solar and wind, have conducted extensive research in social acceptance in the United States (e.g., IEA Wind 2013; Lago et al. 2009; Hoen 2015; Tegen and Lantz 2012; Pattern Development 2015), providing United-States-specific data and mitigation measures.



Acceptance of renewable technologies. Results of a social acceptance survey conducted by Pellizzone et al. (2015). These results show that, in Italy, solar and wind energy technologies are more socially accepted than geothermal, despite Italy having the first operating geothermal plant in the world (Larderello, operating since 1911, in Southern Tuscany, Italy).

6.1 Additional Barriers: Social Acceptance

The results of the opinion polls presented in these various studies demonstrate that public acceptance for renewable energy technologies and policies is high in many countries—broad majorities of people tend to agree with the idea of public support for renewables, even in countries where the government does relatively little to support them. This positive overall picture for renewable energy has misled policymakers to believe that social acceptance is not an issue (Wüstenhagen et al. 2007). In moving from general support to effective positive investment and siting decisions, even the wind and solar industries, which show greater support than geothermal, have had social acceptance barriers (e.g., Tegen and Lantz 2009). For the lesser-known, lesser-accepted geothermal technologies, the disparity is even greater. There are huge differences in deployment rates among countries that cannot be explained by the differences in geothermal resources (Matek 2016).

One analysis conducted in the United States for geothermal reviews public comments on NEPA documents for eight project sites (Heitter et al. 2005). The quantitative results provide a generalized sense of the level of public input and the primary areas of concern. Comments came most often from agencies and special interest (e.g., homeowners' associations) or environmental groups and frequently indicated a lack of knowledge of geothermal development (Heitter et al. 2005). Project opposition was minimized where outreach efforts, including education and interaction with interested parties, occurred at an early stage.

6.1 Additional Barriers: Social Acceptance

Because low levels of social acceptance may be a constraining factor to increase the share of renewables (Pellizzoni 2010), it is an important barrier to overcome if an increase in geothermal deployment is desired.

Recommendations for future work are:

- *Interviews and opinion polls*, such as those carried out for other renewables and those carried out for geothermal in other countries
- *Case studies* of well-implemented community outreach plans (community acceptance), markets that value the baseload-nature of geothermal (and other) generation (market acceptance), and the impact of effective and equitable policies for all renewables (socio-political acceptance)
- *Data-driven analysis* of community, market, and socio-political acceptance
- *Strategies* for overcoming opposition (if present) and improving acceptance (e.g., Pattern Development 2015).

This research will refine our understanding of key social acceptance barriers and evaluate the best ways to mitigate, if desired, the negative perspectives on geothermal power. Collecting these data will allow industry to understand the baseline social acceptance of geothermal, from which the impact of future efforts to improve social acceptance of geothermal can be measured.

6.2 Additional Barriers: Logistics

Logistics were not analyzed in depth as part of the Institutional Barrier Task Force Report but are covered within the GeoRePORT Technical Assessment Tool (TAT). While outside of the direct scope of this report, many of the BET brought up logistics sub-attributes during our discussions as potential soft-cost barriers.

The sub-attribute of the logistics attribute include:

- Proximity to oil and gas fields
- Site road access
- Topography
- Severe weather events
- Wildfire hazards
- Geological hazards (e.g., volcanic, landslide, and earthquake).

Due to the availability of GIS shapefiles for most of these sub-attributes, it would be a relatively straightforward task to develop maps and overlay on the geothermal potential maps for identified and undiscovered resources.

6.3 Additional Barriers: Cost of Time

The cost of time refers to the challenges associated with project delays that may jeopardize the viability of a geothermal project or prevent the project developer from taking advantage of market opportunities.

Examples of the impact of delays include:

- Prevent a project from developing
- Provoke uncertainty and lead to higher risks, which may lead to investors requiring higher returns
- Prevent a project from utilizing an expiring incentive, such as the ITC or PTC
- May lead to increasing financing costs
- May reduce PPA prices and therefore cause lost profits
- May increase transmission interconnection costs
- May cause lost opportunities, such as losing out on a request for proposal because of an inability to provide certainty that a project will be completed in time to meet an RPS requirement.

7.1 Roadmap

Optimization for Geothermal Exploration and Development

Incentives	Design tax credits more suited for geothermal development commensurate with other extractive technologies (e.g., oil and gas) rather than other renewables
Policy	Enhance stakeholder engagement and understanding within the policy domain
Permitting (timelines)	Employ strategies to optimize permitting and regulatory efficiency
	Maintain clear guidelines for permitting and regulatory requirements and processes
Land Access (access/timelines)	Establish and/or prioritize funding for processing leases on National Forest System lands
	Develop innovative strategies to minimize and mitigate siting and environmental impacts
	Develop information and strategies to mitigate the local impact of geothermal deployment and operation
	Increase clarity on authority between DOI and DOD to allow efficient processing of geothermal development on BLM-withdrawn lands
	Develop new maps (e.g., logistics) and update/maintain current maps (e.g., biological, demand) for access to geothermal resources

7.1 Roadmap

Transmission/Grid	Encourage sufficient transmission
	Analyze benefits of baseload generation and grid reliability
	Collaborate with local, state, and federal stakeholders to analyze and address financial and market barriers to geothermal power deployment.
	Improve understanding of and eligibility/participation in renewable and clean energy markets
Outreach and Communication	Partner with other baseload technologies to research and educate on the benefits of baseload technologies for the grid
	Analyze, track, and increase social acceptance of geothermal power in the United States
	Increase acceptance of geothermal heat as a renewable energy resource
	Provide information on geothermal power impacts and benefits

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