U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Association of American State Geologists:

DOE Geothermal Technologies Office Strategy and Key Initiatives

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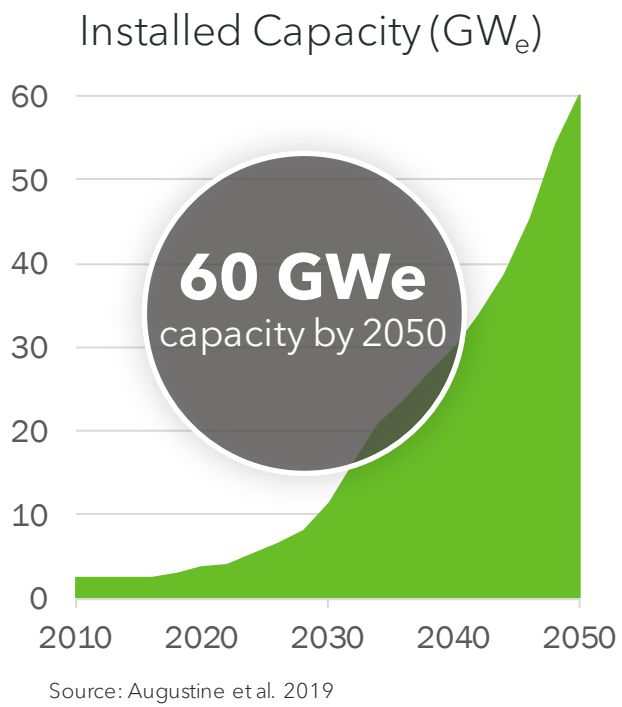
Geothermal Can Do Big Things

ELECTRIC

8.5% of all U.S. generation by 2050

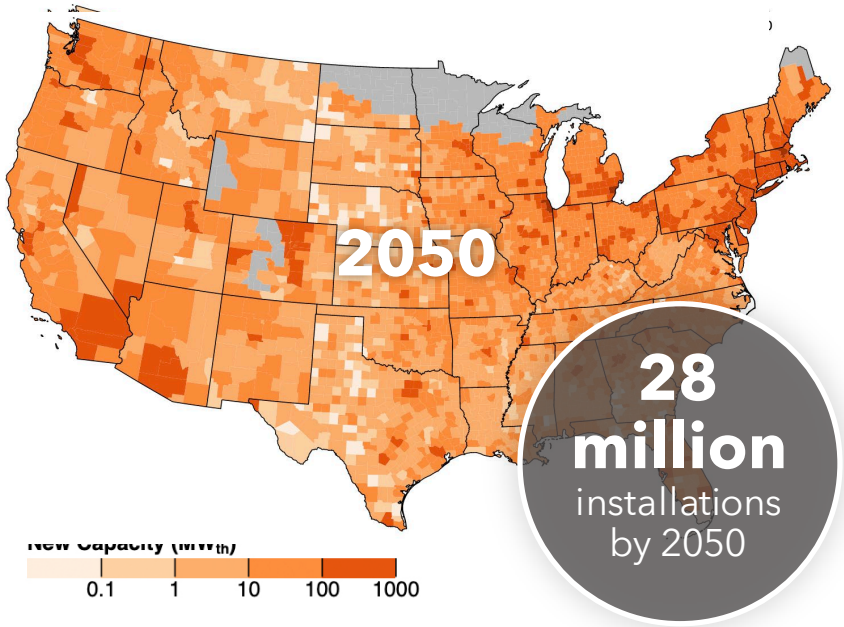


Source: Augustine et al. 2019

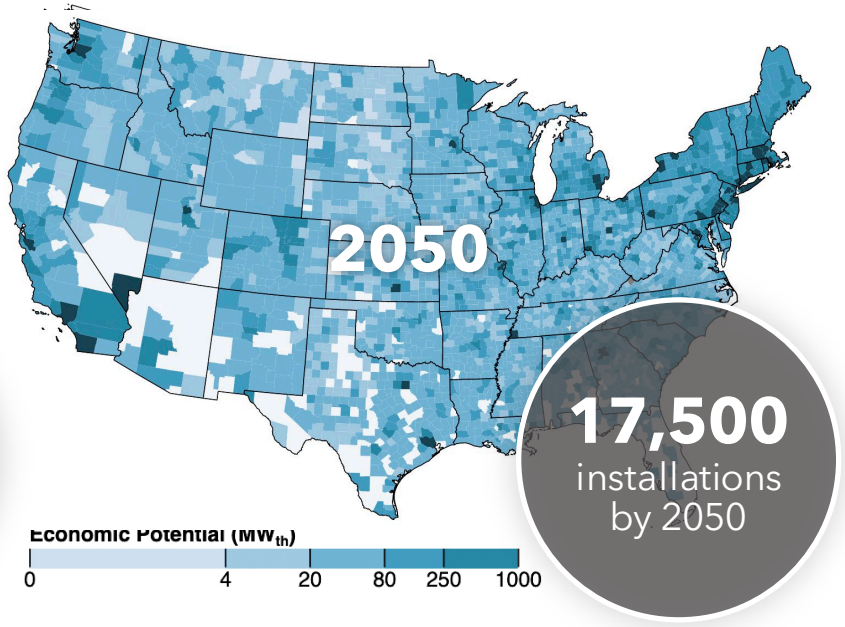
HEATING & COOLING

23% of U.S. Heating and Cooling market by 2050

Geothermal Heat Pumps



District Heating



up to **516 MMT** of avoided CO2e

up to **1,281 MMT** of avoided CO2e

Total Emissions Reductions = removal of **26 million** cars per year

GTO Mission & Program Areas

The GTO mission is to increase geothermal energy deployment through research, development, and demonstration of innovative technologies that enhance exploration and production.

DATA, MODELING & ANALYSIS

This program addresses nontechnical barriers to geothermal deployment including environmental and resource assessments, data stewardship, and analytical tools that advance geothermal exploration and development.

LOW TEMPERATURE & COPRODUCED RESOURCES

This program focuses on applications used with lower-temperature (<300° F) geothermal resources and investigates opportunities surrounding direct-use and geothermal energy storage.

HYDROTHERMAL RESOURCES

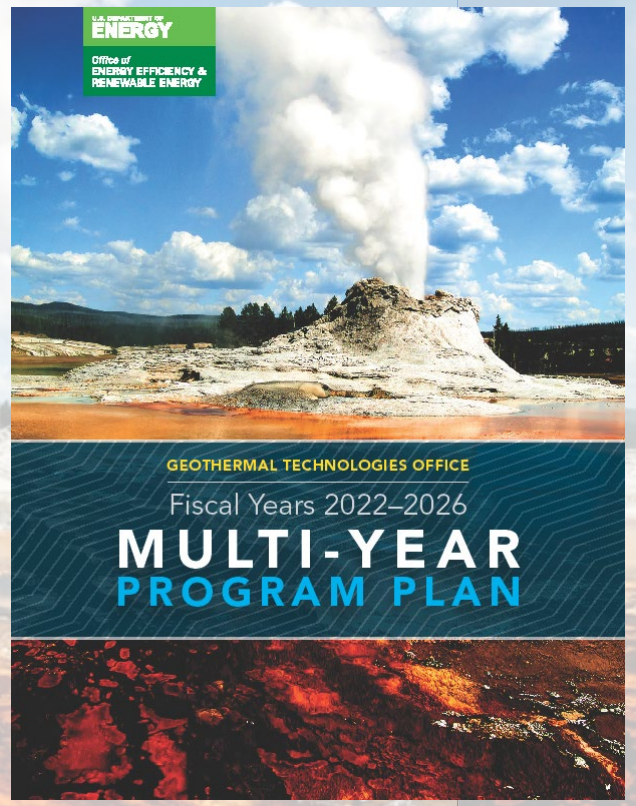
This program aims to increase exploration and confirmation success rates and accelerate the identification and use of undiscovered geothermal resources in the United States.

ENHANCED GEOTHERMAL SYSTEMS

This program works to advance EGS with a focus on reservoir characterization, enhancement, and sustainability.

Achieving Decarbonization Priorities: 5-Year Strategy for GTO

The **Multi-Year Program Plan** is a 5-year plan of activities GTO will pursue to support the growth and long-term contribution of geothermal energy to the U.S. electricity grid and American homes and buildings.



https://bit.ly/GTOMYPP

STRATEGIC GOAL 1

Drive toward a carbon-free electricity grid by supplying 60 GW of EGS and hydrothermal resource deployment by 2050.

STRATEGIC GOAL 2

Decarbonize building heating and cooling loads by capturing the economic potential for 17,500 GDH installations and by installing GHPs in 28 million households nationwide by 2050.

STRATEGIC GOAL 3

Deliver economic, environmental, and social justice advancements through increased geothermal technology development.

GTO's Multi-Year Program Plan: Six Research Areas

Exploration and Characterization

Technical Objective: Improve resource targeting for all geothermal resource types

Key Activities
- Geophysics and Remote Sensing
- Geochemistry
- Geology

Barriers
- Geothermal resources are largely hidden
- Data acquisition costs are high and limited public data exists

Accessing the Resource

Technical Objective: Improve drilling costs toward the "ideal" cost curves used in the *GeoVision* analysis

Key Activities
- Drilling Time
- Well Components
- Enabling Technologies

Barriers
- Geothermal drilling technology improvements are needed
- Drilling costs must be reduced

Subsurface Enhancement & Sustainability

Technical Objective: Enhance and sustain geothermal energy recovery

Key Activities
- Reservoir Response
- Reservoir Development and Management Technologies
- Reservoir Characterization and Monitoring

Barriers
- Subsurface engineering is required to unlock EGS potential
- Stimulation and reservoir operation technologies are available for geothermal conditions

Resource Maximization

Technical Objective: Accurately capture the value of geothermal energy resources

Key Activities
- Heating and Cooling
- Grid Valuation
- Thermal Storage and Utilization
- Value Streams

Barriers
- Uptake of geothermal systems requires robust case studies
- Reservoir thermal energy storage demonstrations to prove range of applications
- Lithium extraction requires scalable technologies

Data, Modeling, and Analysis

Technical Objective: Expand the capabilities of using data to identify and address barriers to geothermal deployment

Key Activities
- Economic Analysis and Validation
- Data Collection, Access, and Analysis Tools
- Policy and Regulatory Analysis

Barriers
- Insufficient data for project cost and collaboration regarding permitting
- Lack of representation in modeling tools
- Insufficient economic analysis of value streams

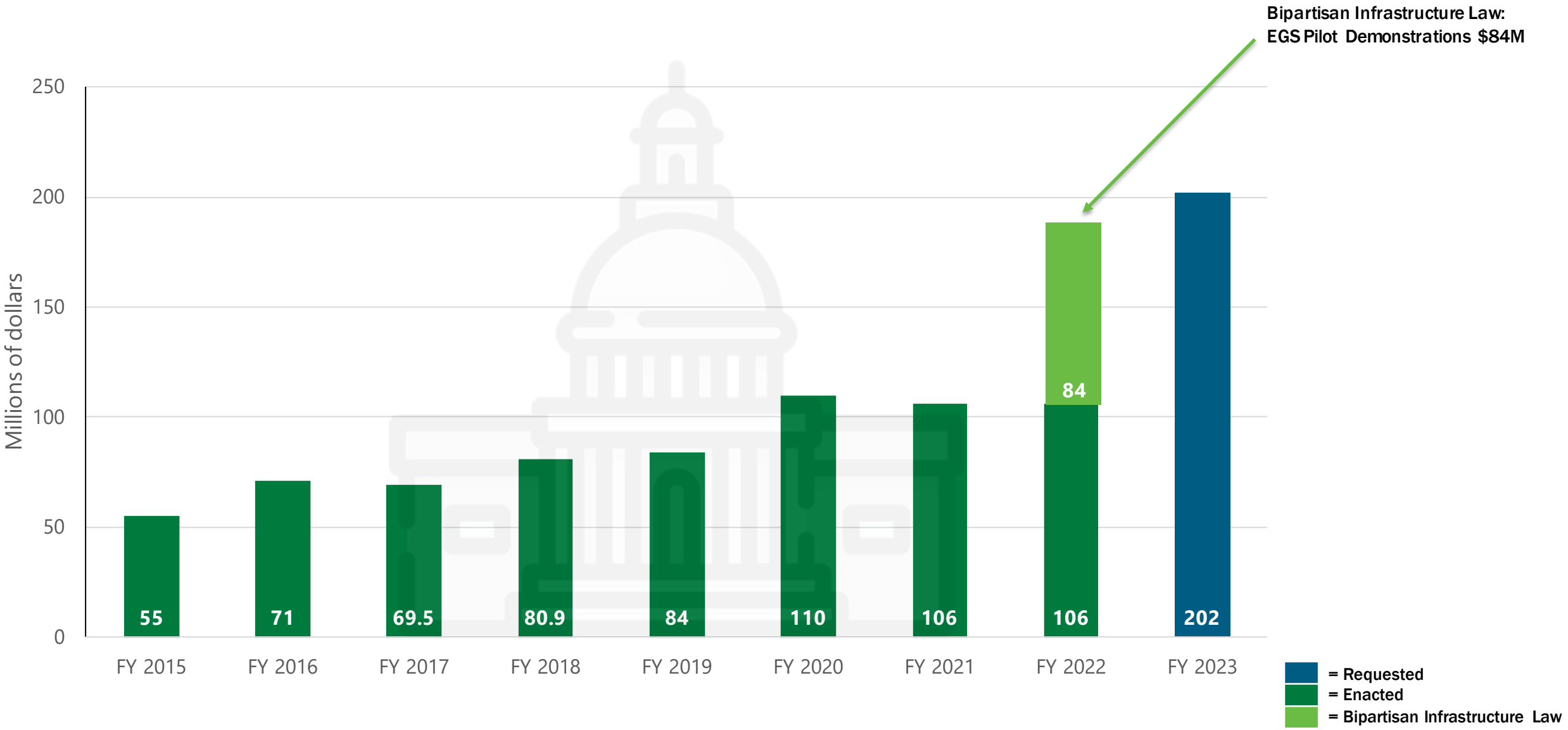
Geothermal Integration & Awareness

Technical Objective: Expand stakeholder education and outreach to improve understanding of geothermal energy and advance geothermal technologies

Key Activities
- Machine Learning
- Advanced Manufacturing
- Technology Commercialization
- Energy Transitions
- Stakeholder Engagement

Barriers
- Need for workforce training, cost reductions, and advance manufacturing across geothermal resources
- Limited public awareness of understanding of geothermal

GTO FY 2022 and FY 2023 Budget: Update



Geothermal Technologies Office – FY 2022 Highlights

- **Drilling Technology Demonstration Campaign ($16.5M from FY 2022; $3.5M from FY 2021):** This initiative targets technology developments that will provide significant improvements in drilling performance in commercial geothermal settings. Final Applications due: June 3.
- **Frontier Observatory in Research in Geothermal Energy (FORGE) ($20M):** Utah FORGE drilled the first-ever highly deviated geothermal well at a rate twice the industry standard. In FY 2022, GTO will support the next R&D solicitation, contributing to meeting Administration goals for a carbon-free electric grid.
- **Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE) ($10M from FY 2022; $155M for outyears):** This is a new consortium designed to leverage the oil & gas subsurface industry to help solve geothermal energy's toughest challenges.
- **Community Geothermal Heating and Cooling Design and Deployment ($13M):** This initiative funds technical assistance to demonstrate, deploy, and implement community-scale direct use geothermal district energy systems through installation of geothermal heat pumps (GHP) and/or direct use of geothermal fluids.
- **Federal Partnerships for Geothermal Installations ($4M from FY 2022; $2M from FY 2021):** GTO and FEMP will make it possible for federal agencies (DOD, GSA, State, NASA, DOE labs, Park Service) to consider geothermal energy to heat and cool (and, in limited cases, potentially power) their installations.

A drilling rig at the FORGE site outside of Milford, Utah

Geothermal Technologies Office – FY 2023 Highlights & Major Changes

- **EGS Greenfield Demonstration Projects: ($25M):** Building on the zonal isolation/stimulation learnings of previous GTO initiatives such as Wells of Opportunity, FORGE, and EGS Collab, these new EGS demonstrations will move beyond the near-field environment to get closer to greenfield EGS in multiple environments, helping scale up EGS and ensure its viability throughout the nation.
- **Reservoir Thermal Energy Storage (RTES) ($12M):** Unlock the terawatt-scale thermal energy storage of using the Earth as our battery. New pilots and demonstrations will build on prior years of early-stage research to demonstrate technical feasibility, grid integration, and long-term storage opportunities for renewable energy systems.
- **EGS Drilling and Well Construction: ($15M):** This initiative builds on the work of the FY 2022 Hydrothermal Resources Drilling Demonstration projects, targeting drilling and completion technologies that will enhance exploration and development specific to EGS resources.
- **FORGE: ($25M):** Drill a third, long-reach horizontal well, providing an opportunity to further advance the 5x improvement in drilling speed demonstrated at FORGE in 2021 and enable additional stimulation and zonal isolation testing. These efforts will help demonstrate the viability of EGS as a scalable technology and enabling 60 GWe of geothermal power by 2050.
- **FedGeo Power: ($12M):** Conduct feasibility studies and site characterization for geothermal power generation opportunities at federal and military sites with a large electricity demand and/or strong energy security and resiliency mandates. The federal government's energy use in 2019 was 889 trillion Btu. Converting even a few of large campuses to geothermal power could have significant impact.
- **GEODE: ($10M from FY 2022; $25M requested from 2023):** GEODE will develop the strategy and establish the implementation mechanism to effectively transition the oil and gas technologies and workforce into geothermal. Key focus areas include (1) leveraging oil and gas technologies to lower geothermal costs and (2) workforce training.
- **Community Geothermal Heating & Cooling - Food/Ag Focus: ($17M):** Fund demonstrations of direct use heating and cooling for both community and industrial agriculture to address local energy scarcity and food security needs in underserved areas of the United States.

GTO Open/Upcoming Opportunities and Recent Announcements

Geothermal Geophone Prize: Offers $3.65 million in incentives to develop high-temperature seismic sensors (geophones) that collect real-time data monitoring for enhanced geothermal systems.

- Submissions due by Sept. 29
- For more information, visit https://www.herox.com/GeophonePrize

Funding Opportunities Coming Soon!

- **Bipartisan Infrastructure Law (BIL) - 2022 Enhanced Geothermal Systems (EGS) Pilot Demonstrations:** Request for information closed on May 13.
- **Community Geothermal Heating and Cooling Design and Deployment:** Notice of intent released on May 3.
- **Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE):** Coming this summer

Other Announcements

- **Geothermal Lithium Extraction Prize:** This prize is designed to find solutions that de-risk and increase market viability for direct lithium extraction (DLE) from geothermal brines.
  - Finalists to be announced this summer.
- **Drilling Technology Demonstrations:** This initiative targets technology developments to provide significant improvements in drilling performance in commercial geothermal settings
  - Funding opportunity closed June 3; selections expected in the fall

GTO: Hydrothermal Resources Program

Hydrothermal resources exist where there is sufficient temperature, permeability, and fluid in the subsurface such that fluids can flow naturally at economic rates for power generation.

- GTO's Hydrothermal Resources Program funds projects that focus on accurately predicting temperature and permeability at depth from the surface to reduce exploration risk, subsurface characterization and imaging, and improvement in drilling technologies to reduce the costs and time to development geothermal resources.
- The program supports the collection of data to help characterize geothermal resources, machine learning projects, subsurface imaging, and research on lithium extraction from geothermal brines.
- New FY 2022 funding opportunities include the Drilling Technology Demonstration Campaign and the GEODE initiative.

HYDROTHERMAL RESOURCES

This program aims to increase exploration and confirmation success rates and accelerate the identification and use of undiscovered geothermal resources in the United States.

Hidden Systems

INnovative Geothermal Exploration through Novel Investigations Of Undiscovered Systems (INGENIOUS)

- This project seeks to accelerate discoveries of new, commercially viable, hidden systems across the broader Great Basin region and create a comprehensive guide for geothermal operators and future research teams that includes predictive geothermal maps at both regional and prospect scale.
- Researchers are compiling and synthesizing datasets and plan to complete drilling this summer.

Basin & Range Investigations for Developing Geothermal Energy (BRIDGE)

- This project is investigating areas in Nevada, collecting data and conductive surveys to locate hidden geothermal systems. The work is intended to help drive down costs and risks associated with the discovery of hidden geothermal systems.
- This project aims to improve baseline technology across three main components of the exploration process: efficiency of discovery of new hidden resources; effectiveness of characterization and ranking of resources so that the best ones can be prioritized for detailed study and drilling; and completion of test drilling and resource modeling to determine the probability of success for developing a prospect.
- Researchers are completing their Helitem surveys and development of initial conceptual models, and will begin focused prospect exploration this summer

Hidden Systems—cont.

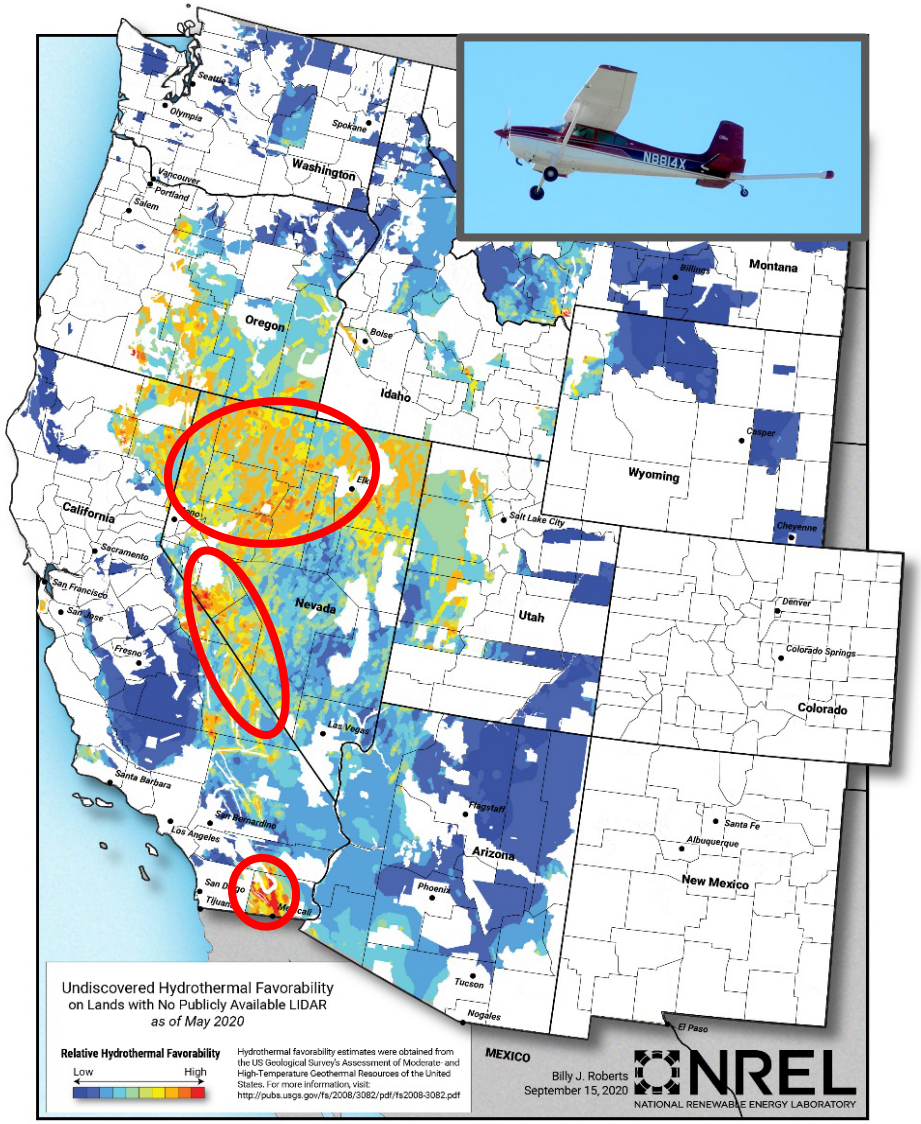
GTO collaborates with the U.S. Geological Survey to help provide solutions to meet U.S. needs for both energy and critical minerals.

Geoscience Data Acquisition in Western Nevada (GeoDAWN)

- Researchers gathered new subsurface data specifically in the Walker Lane geologic zone in western Nevada, an area that is rich in both geothermal and mineral resources, and they will leverage machine learning to develop deeper understanding of the geologic conditions and stress regime.
- The geophysical data will be used to locate undiscovered geothermal resources while also identifying critical mineral deposits that can be mined for domestic use.

GeoFlight: Salton Trough

- Building on the success of GeoDAWN, the GeoFlight initiative, launched in 2021, seeks to collect data on hidden geothermal systems in California's agriculturally rich Imperial Valley, which includes the Salton Sea.
- Using specially equipped, low-flying aircraft, researchers are surveying to help identify unique surface and near-surface characteristics to create more accurate geologic maps for the area.
- Understanding these characteristics is essential to geothermal exploration and development.

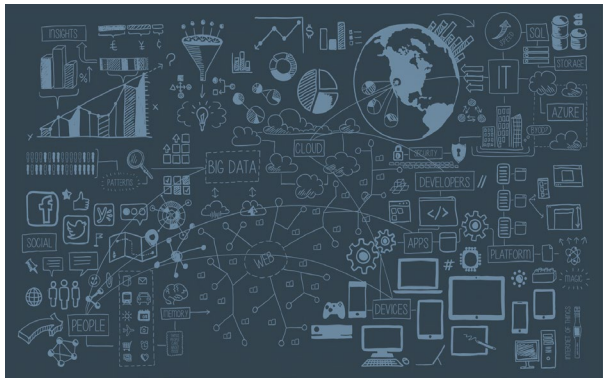


Machine Learning

Machine Learning offers substantial opportunities for technology advancement and cost reduction throughout the geothermal project lifecycle.

R&D Objectives:

- Identify data acquisition targets with high value for future work and development.
- Identify new signatures and pathways for detecting hidden geothermal systems.
- Optimize power production through plant/reservoir monitoring and analytics.
- Improve prediction and detection of trouble events.



Since FY 2018, GTO has invested in projects to apply machine learning techniques to geothermal exploration and production. If applied successfully, machine learning could lead to higher success rates in exploratory drilling, greater efficiency in plant operations, and ultimately lower costs for geothermal energy. Projects, including four funded in FY 2021, have focused on applying machine learning to such topics as:

- Geothermal exploration
- Advanced analytics for efficiency automation in geothermal operations
- Development of deep learning models
- Detection and characterization of fracture zones

Thank You!

Get the hottest geothermal news from *The Drill Down*, the new monthly newsletter from GTO!

Sign up today: geothermal.energy.gov

Interested in serving as a merit reviewer for GTO RD&D projects?

Send us your resume or CV: doe.geothermal@ee.doe.gov

Attend Geothermal Rising Conference, the largest annual gathering of the geothermal community.

GTO plans to have a booth and will host an event to announce upcoming Prize opportunities.

We hope to see you there!!