U.S. DEPARTMENT OF ENERGY

Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Drilling for Opportunities: The Geothermal Technologies Office

Lauren Boyd, Director

Presentation to: Stanford Geothermal Workshop

February 12, 2024

Geothermal is Hot!

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ENERGY SWITCH

What's New in Geothermal?

Season 3 Episode 6 | 26m 46s | CC

+ My List

Geothermal energy can be found everywhere below the surface, at varying temperatures, depending on how deep and where you are. We can use it to warm homes and buildings, generate electricity, and hopefully to produce high heat for industrial processes. Lauren Boyd, Acting Director of Geothermal Technologies at the DOE, and Carlos Araque, Co-founder and CEO of Quaise Energy, discuss

0:00 / 26:46

India China

pv magazine

Noticias Características Eventos Imprimir archivo Sobre Nosotros Pu

Desde la ciencia una colaboración por consolidar: Litio en México y Estados Unidos

La voz experta de Patrick Dobson, científico estadounidense que como pocos en el mundo elemento llamado a conv

ESMAP publishes report on socioeconomic benefits of geothermal

CLIMATE & ENVIRONMENT

The Salton Sea has even more lithium than previously thought, new report finds

AP WORLD U.S. ELECTION 2024 POLITICS SPORTS ENTERTAINMENT BUSINESS SCIENCE FACT CHECK ODDITIES HEAL

U.S.-Middle East King Charles III 'Pineapple Express' Grammys moments Taylor Sw

CLIMATE

Here's how geothermal energy heats and cools a home

GeoDrilling International

Events

GEOTECHNICAL & ENVIRONMENTAL | CONSTRUCTION & FOUNDATIONS | MINING | GROUNDWATER &

US analysis highlights geothermal heat pumps as future of decarbonised energy

The US Department of Energy (DoE) has announced the results of an analysis highlighting that, deployed at mass scale, geothermal heat pumps (GHP) could decarbonise heating and cooling and save energy in US buildings while reducing the need for new grid transmission.

THE FUTURE OF EVERYTHING WSJ

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OCTOBER 13, 2023

6:00:00 AM Share This Episode

g Electric? Why Future Power Could Come From Hot Rocks

POLITICOPRO

Salton Sea's lithium supply could fuel US clean energy expansion, DOE lab says

Finding and developing domestic sources of lithium is essential to the major clean ene expansion needed to meet President Joe Biden's climate goals.

BY: KELSEY TAMBORRINO | 11/28/2023 12:01 PM EST

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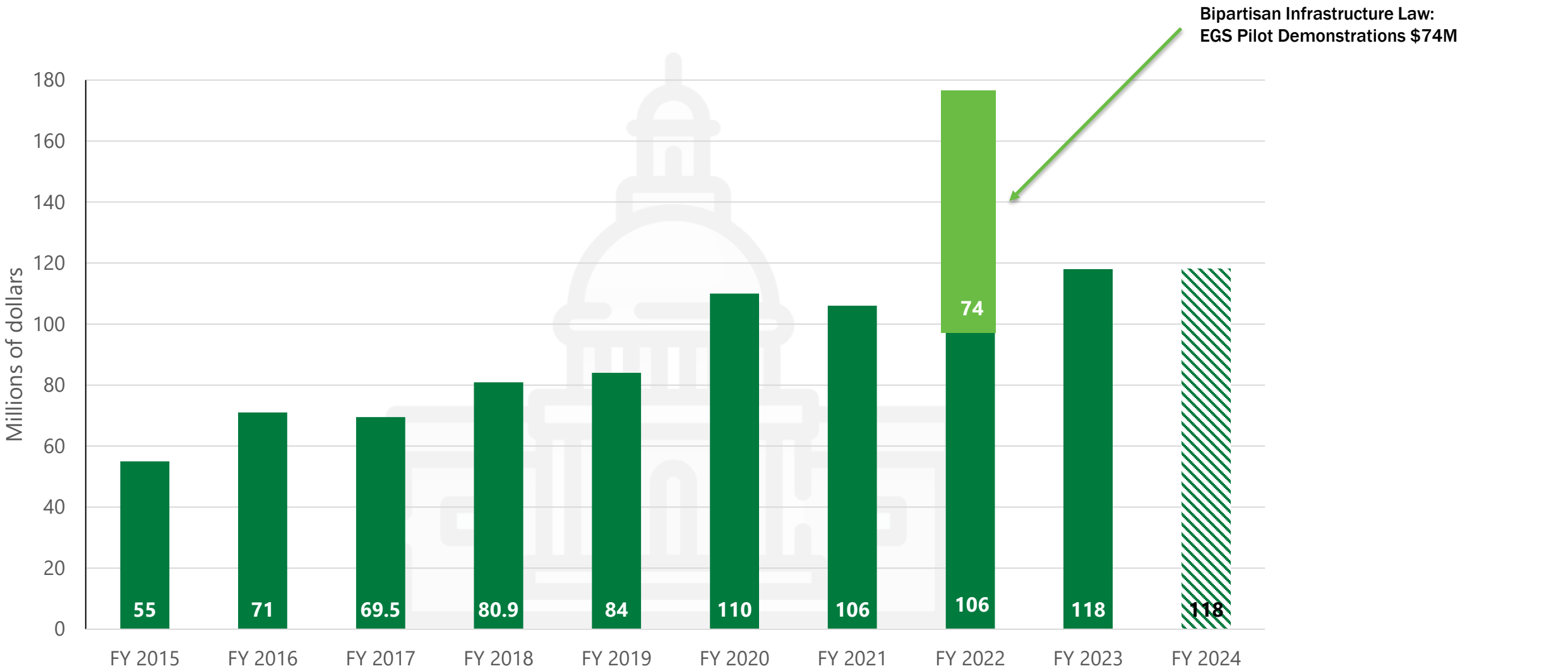
GTO Budget



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

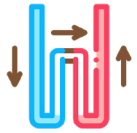
RESEARCH AREA	TECHNICAL OBJECTIVES
EXPLORATION AND CHARACTERIZATION	Improve resource targeting for all geothermal resource types
SUBSURFACE ACCESSIBILITY	Improve drilling costs toward the "ideal" cost curves used in the *GeoVision* analysis
SUBSURFACE ENHANCEMENT AND SUSTAINABILITY	Enhance and sustain geothermal energy recovery
RESOURCE MAXIMIZATION	Accurately capture the value of geothermal energy resources
DATA, MODELING, AND ANALYSIS	Expand the capabilities of using data to identify and address barriers to geothermal deployment
GEOTHERMAL INTEGRATION AND AWARENESS	Expand stakeholder education and outreach to improve understanding of geothermal energy and advance geothermal technologies

GTO's Program Areas

GTO aims to increase **all** geothermal energy deployment through research, development, and demonstration of innovative technologies that enhance exploration and production.

Enhanced Geothermal Systems

Hydrothermal Resources



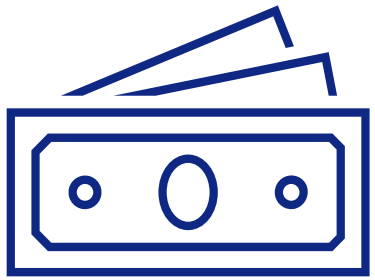
Low-Temperature and Coproduced Resources

Data, Modeling, and Analysis

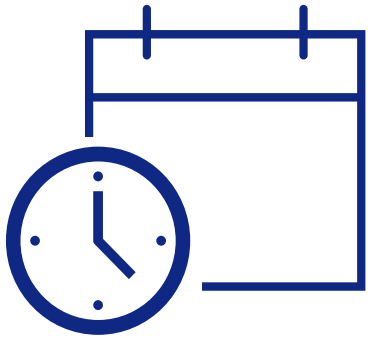
Enhanced Geothermal Shot™

ENERGY earthshots
U.S. DEPARTMENT OF ENERGY

Enhanced Geothermal



$ 45/MWh



2035

Enhanced Geothermal Shot Analysis for the Geothermal Technologies Office

Chad Augustine, Sarah Fisher, Jonathan Ho, Ian Warren, and Erik Witter

National Renewable Energy Laboratory

nrel.gov/docs/fy23osti/84822.pdf

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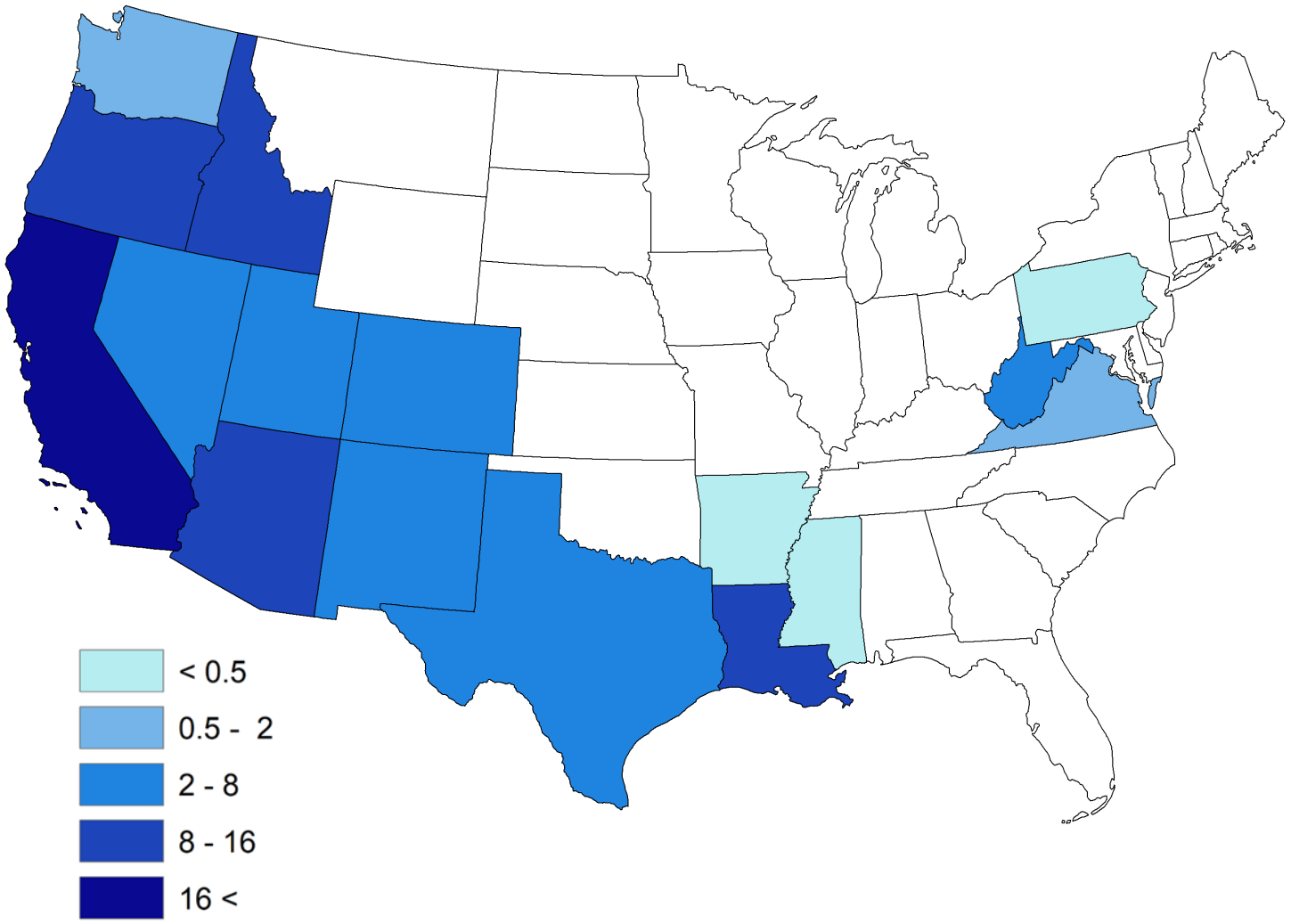
Enhanced Geothermal Shot™

2050 Deep EGS Deployment Capacity (GW)



90 GW_e by 2050

- Expansion of geothermal for electricity generation
- Clean heating & cooling for U.S. households
- Drives just transition and leverages fossil workers

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DOE Office of Science Energy Earthshot Research Centers

U.S. DEPARTMENT OF ENERGY | Office of Science

- Each Center led by a DOE national lab, with partners from academia and industry
- Comprise collaborative research teams spanning multiple scientific and engineering disciplines
- Leverages DOE national laboratories to address complex research challenges targeting Energy Earthshot stretch goals
- Each Center to address key research challenges of one of the initial six Energy Earthshots.

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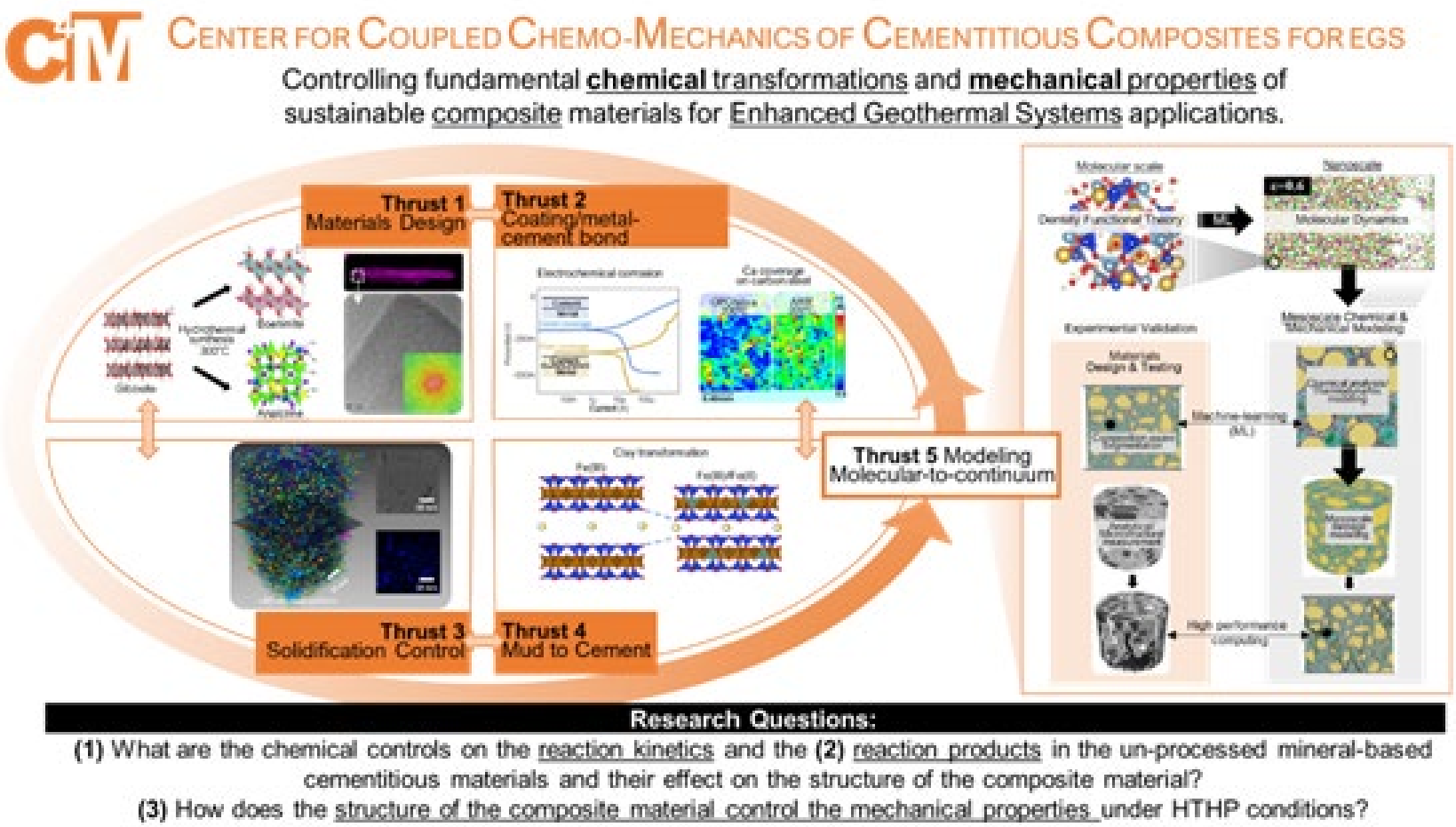
DOE Office of Science Energy Earthshot Research Centers



Brookhaven National Laboratory

Supports Enhanced Geothermal Shot™ goal and advances U.S. geothermal energy development by elucidating and controlling chemical transformations and mechanical properties of sustainable composite materials for EGS

Partners include Lawrence Berkeley National Laboratory, Sandia National Laboratories, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, University of Texas at Austin, Cornell University, University of Illinois Urbana-Champaign, and Princeton University

DOE Office of Science Energy Earthshot Research Centers

CUSSP · Center for Understanding Subsurface Signals and Permeability

Pacific Northwest National Laboratory

Aims to create the ability to predict and control fluid flow through fracture networks in EGS through:

- Understanding how fluid interaction with hot rocks under stress can change flow behavior over time
- Learning how to detect and monitor those changes remotely by developing advanced real-time sensing tools.

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Geothermal in the Bipartisan Infrastructure Law

SEC. 41007. Enhanced Geothermal Systems Demonstrations

Topic 1: EGS Proximal Demonstrations: EGS demonstrations utilizing existing infrastructure proximal to existing geothermal/hydrothermal development with immediate potential for electrical power production.

Topic 2: EGS Green Field Demonstrations: Sites with no existing geothermal development and potential for shallow sedimentary, igneous and/or mixed metamorphic rock EGS with near-term electrical power production potential.

Topic 3: Super-hot / Supercritical EGS Demonstrations: Super-hot/ Supercritical EGS demonstrations located at well-characterized sites with near-term electrical power production potential.

Topic 4: Eastern U.S. EGS Demonstrations: Demonstration at a well-characterized eastern U.S. site, with existing wells in place and near-term electrical power/heat production potential.

DOE Round One (Topics 1-3) selection announcement expected TOMORROW!

EGS Enhanced Geothermal Systems

PILOT DEMONSTRATIONS

Round two FOA forthcoming

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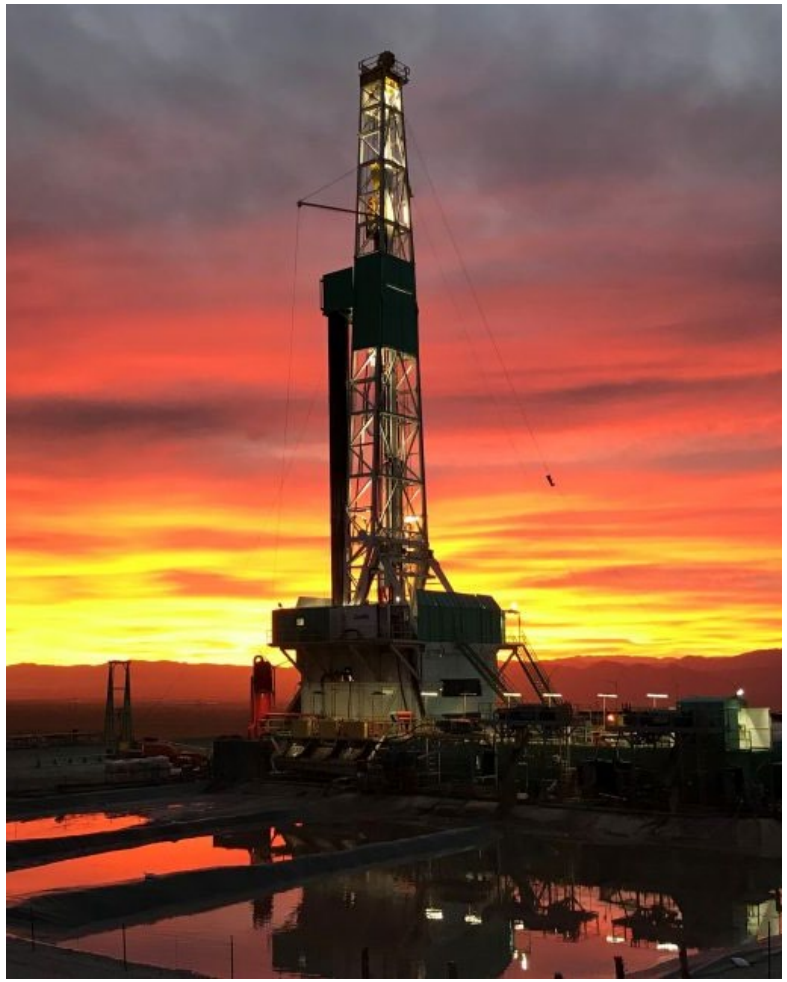
Frontier Observatory for Research in Geothermal Energy (FORGE)

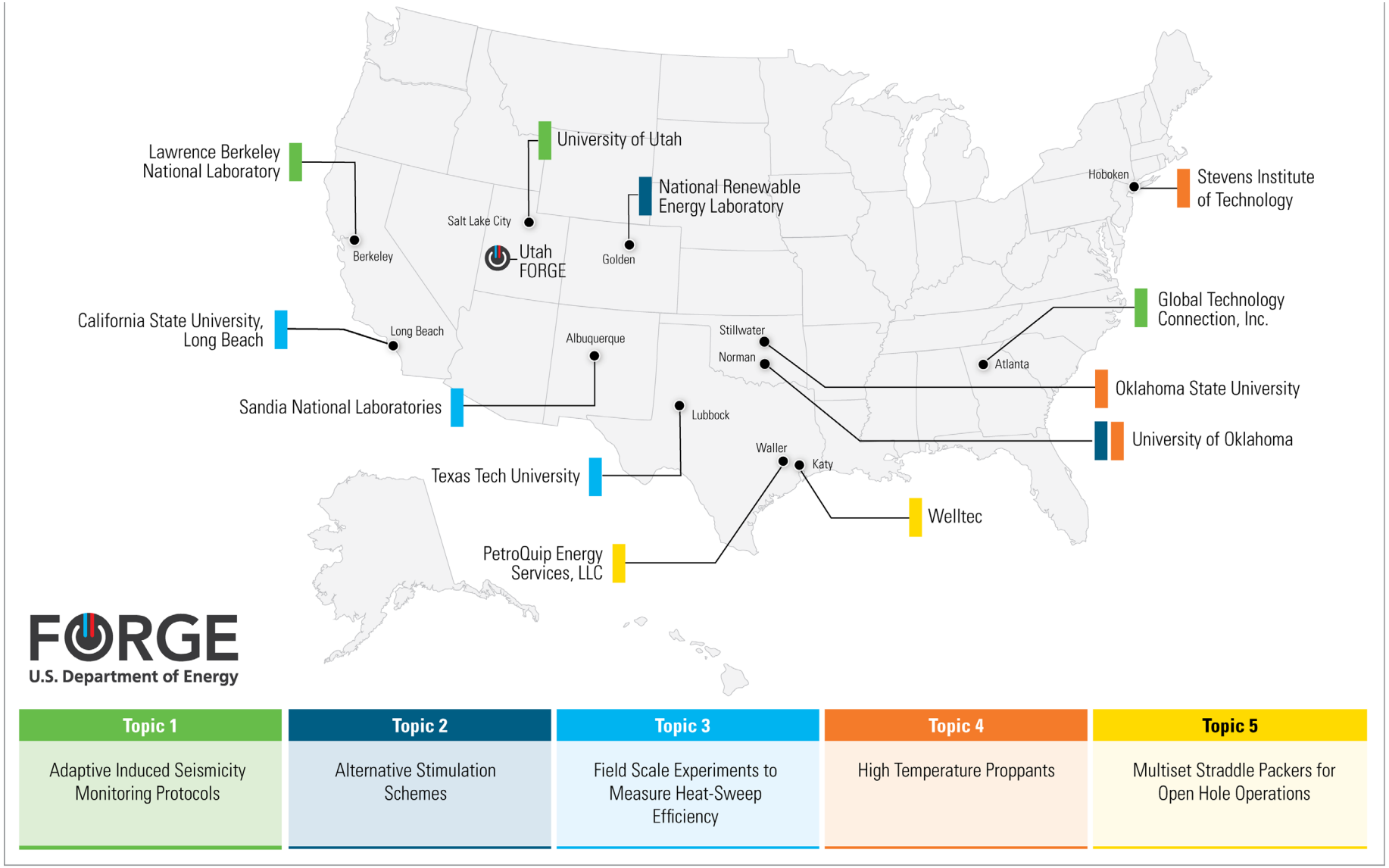
- Drilling updates
  - Completed drilling of 16B production well
  - Intersects existing injection well (16A) through reservoir of hydraulically created fractures
  - Confirmed connectivity of the doublet pair
  - Continued stimulations and circulation testing planned
- **13 projects** selected in November 2023 to receive up to **$44 million** for projects to develop and test technology fostering innovation in EGS in **five topic areas**:
  - Adaptive Induced Seismicity Monitoring Protocols
  - Alternative Stimulation Schemes
  - Field Scale Experiments to Measure Heat-Sweep Efficiency
  - High Temperature Proppants
  - Multiset Straddle Packers for Open Hole Operations

UTAH FORGE U.S. Department of Energy



Eric Larsen, Flashpoint SLC

FORGE Solicitation 2022-2 Prime Selectees

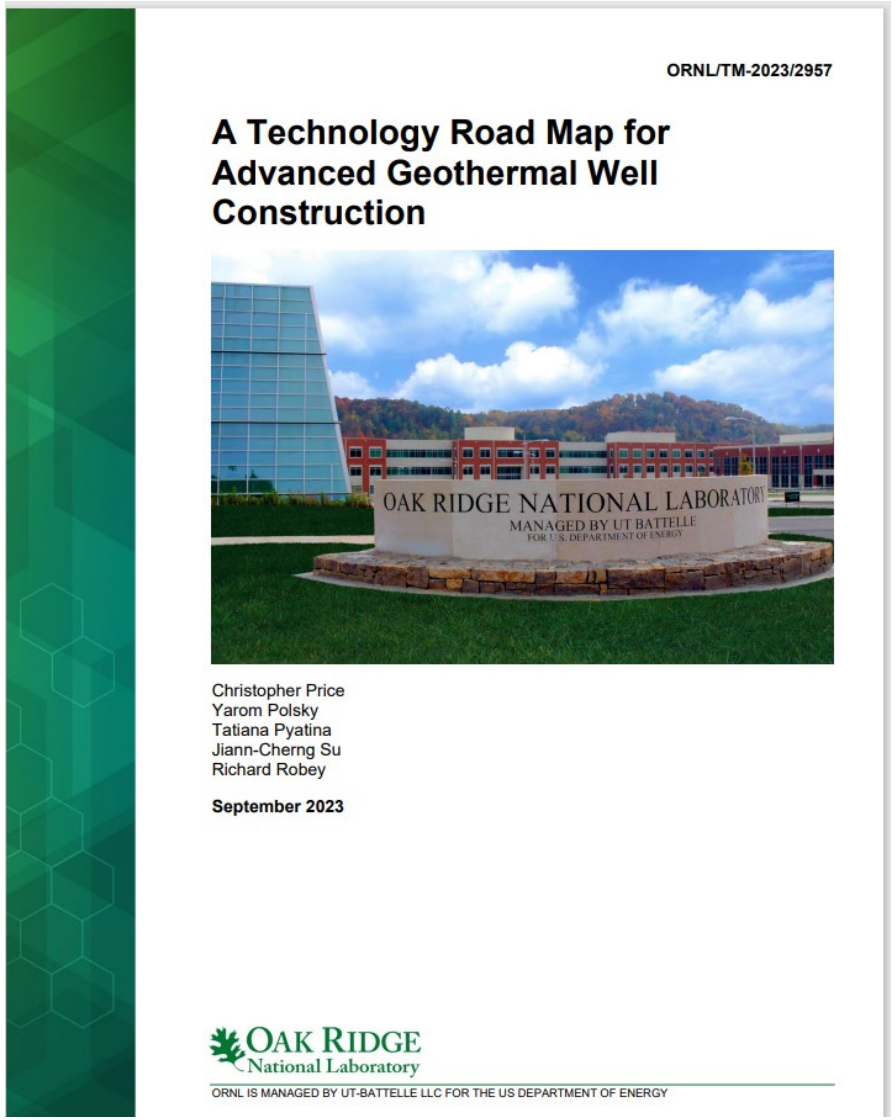


Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
Adaptive Induced Seismicity Monitoring Protocols	Alternative Stimulation Schemes	Field Scale Experiments to Measure Heat-Sweep Efficiency	High Temperature Proppants	Multiset Straddle Packers for Open Hole Operations

energy.gov/eere/articles/us-department-energy-announces-13-projects-receive-44-million-innovations-enhanced

Advanced Geothermal Well Construction Roadmap

- Focused on RD&D activities needed to reduce life cycle casing and cementing costs while improving life-of-well performance
- Three categories identified as activities related to (1) high-performance and cost-effective materials for geothermal well conditions, (2) well construction methods and techniques that reduce well cost without increasing future operational and ownership costs, and (3) methods and techniques that decrease long-term operating costs without significantly increasing the cost of well construction
- Purposefully excludes RD&D efforts to improve rock reduction (e.g., drilling ROP and bit life)
- Sets RD&D targets for the next 10 years.



info.ornl.gov/sites/publications/Files/Pub196313.pdf

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Advanced Geothermal Well Construction Roadmap

Thirty-five experts participated in info-gathering activities, including surveys and teleconferences, and discussed these questions in depth over the course of four working group meetings:

- What are the major technology challenges that affect efforts to reduce well construction costs?
- What are the major market challenges that affect efforts to reduce well construction costs?
- What are the key performance targets that should be established to guide an RD&D program with the objective of reducing well construction costs?
- What are the strategic areas of focus or interest that should be pursued as part of an RD&D program with the objective of reducing well construction costs?

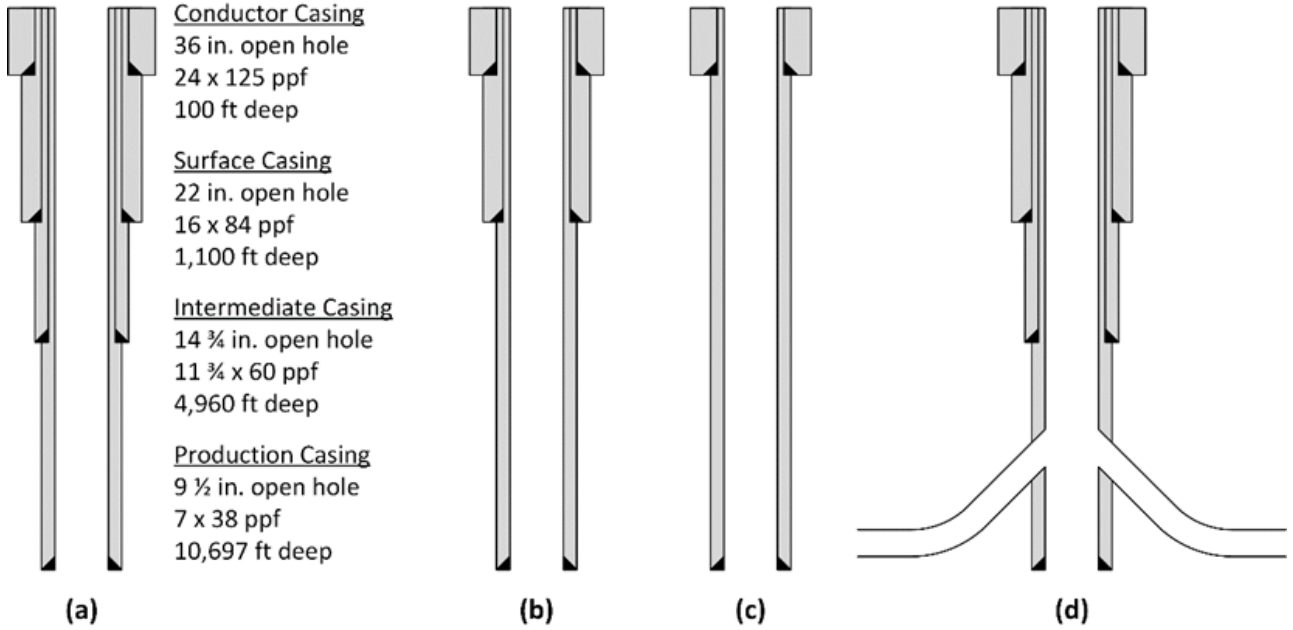
Rig-tripping at FORGE. Courtesy Gosia Skowron.

info.ornl.gov/sites/publications/Files/Pub196313.pdf

Advanced Geothermal Well Construction Roadmap

Well time and cost estimation tool (top) and well construction scenarios (bottom)

CASING INPUTS	UNITS	0	1	2	3	4	5
Liner?	yes/no	no	no	no	no		
Tieback?	yes/no						
Casing - Outer Diameter	inches	24.00	16.00	11.75	7.00		
Casing - Weight	lbs/foot	128.00	84.00	60.00	38.00		
Casing - Mateiral Density	lbs/foot^3	500.00	500.00	500.00	500.00		
Casing - Length Shoe Track	feet		25	25	25		
Casing - Height Liner Hanger	feet						
Casing - Rate	feet/hour	100	100	100	100		
Casing - Time Standup + Laydown	hours	4.0	4.0	4.0	4.0		
Casing - Time Wellhead Pressure Test	hours	1.0	1.0	1.0	1.0		
Casing - Time Wellhead Operations	hours	12.0	12.0	24.0	24.0		
Casing - Time BOP Installation	hours	24.0	24.0	24.0	24.0		
Casing - Cost Casing	$/lb	$ 2.00	$ 2.00	$ 2.00	$ 2.00		
Casing - Cost BOP Rental	$/day	$ 2,000	$ 2,000	$ 2,000	$ 2,000		



Areas of Focus Developed

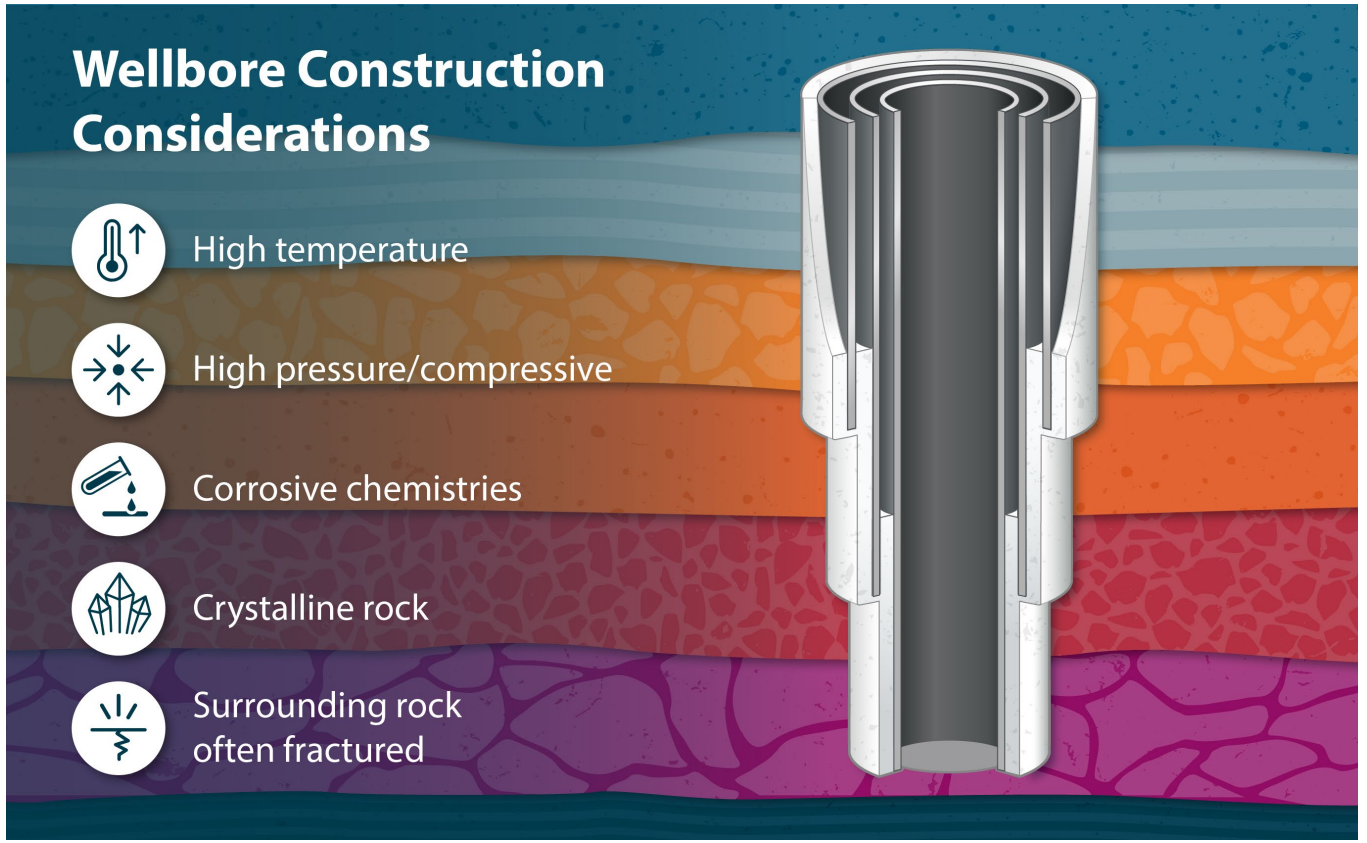
- **Reducing Material Cost**: developing fit-for-purpose materials or qualifying existing materials to increase options
- **Managing Lost Circulation**: continuing or expanding programs, initiating new programs building on past work
- **Well Design Improvements**: reducing number of casing strings, enabling novel well construction approaches
- **Well Integrity Logging and Monitoring Tools**: pursuing RD&D to reduce well life cycle costs and improve social license to operate
- **Well Performance Analysis and Design Improvements**: conducting analysis on and quantifying well performance, esp. workovers

Combined Wellbore Construction and RTES Funding Opp

Wellbore Construction: Up to $23.1 million

Targets wellbore tools and technology that:

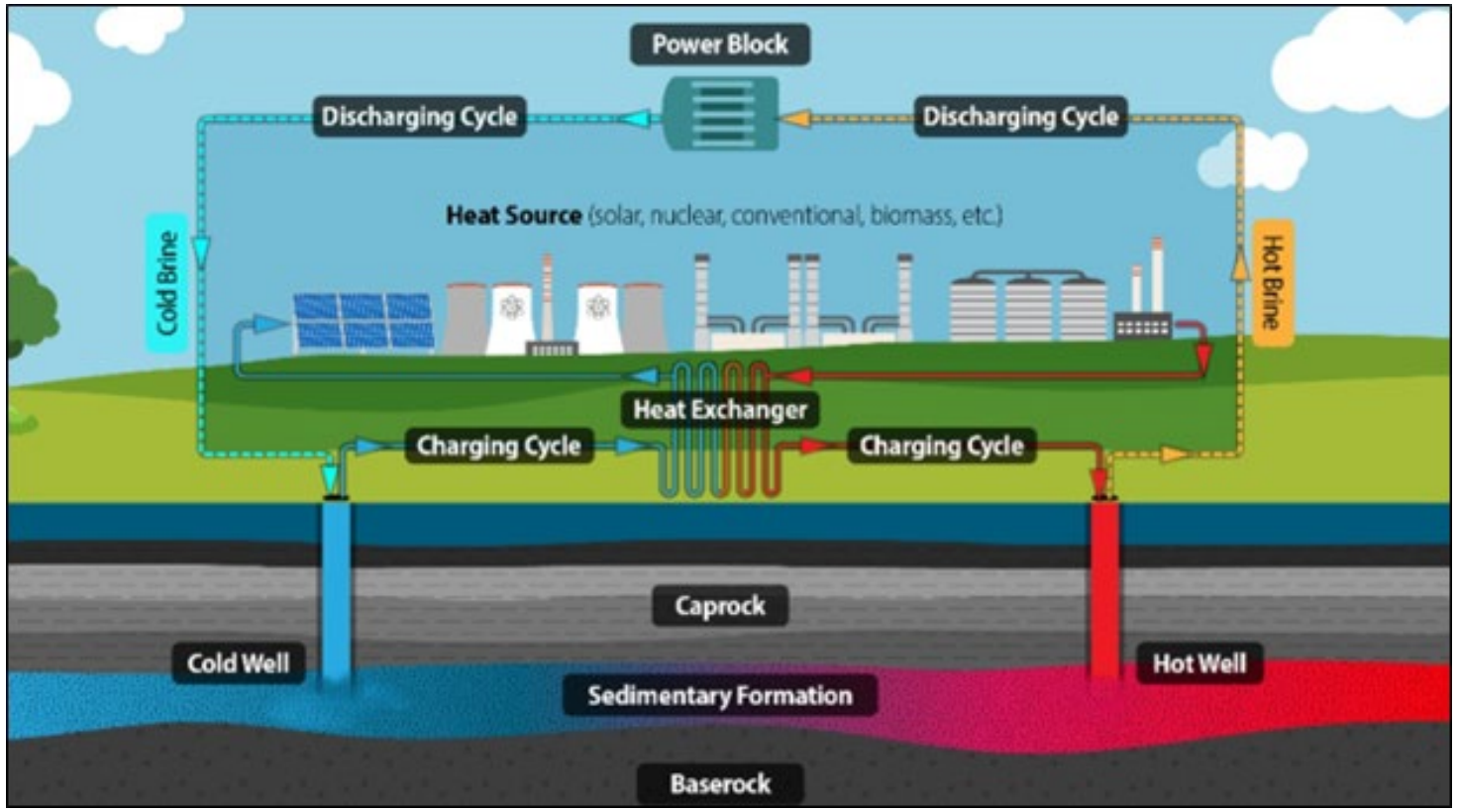
- Supplement and advance beyond available off-the-shelf solutions for cement and casing evaluation
- Operate in high-temperature geothermal environments
- Operate in a manner not reliant on extraneous wellbore cooling or substantial mitigation of borehole conditions
- Provide high-fidelity data to adequately characterize conditions related to safety and efficacy for long-term operation.



Topic Area 1: High Temperature Tools for Well Integrity Evaluation

Learn more on GTO's funding opportunities page: geothermal.energy.gov

Combined Wellbore Construction and RTES Funding Opp



Topic Area 2: Utilization of Reservoir Thermal Energy Storage Technology and Low-Temperature Geothermal Resources as part of an Industrial Process

Reservoir Thermal Energy Storage (RTES):
Up to $7.9 million

Seeks to demonstrate low-temperature (<130◦ C) RTES technology:

- To reduce emissions from energy-intensive processes using industrial heating, e.g., removing moisture, separating chemicals, treating metals
- With reservoir formations below aquifer systems used for potable water
- Offering a minimum of 10 hours of thermal storage, with preference given to longer-duration storage systems

Learn more on GTO's funding opportunities page: geothermal.energy.gov

Drilling Demonstrations Campaign

- Will reduce cost of developing geothermal energy by generating **at least a 25% improvement** in geothermal drilling rates

- Two projects:
  - **Geothermal Limitless Approach to Drilling Efficiencies (GLADE)**
    - Denver-Julesburg Basin, CO
  - **Evaluation of Physics-Based Drilling and Alternative Bit Design**
    - The Geysers Geothermal Field, CA
    - One well already drilled successfully!

Community-Scale Geothermal

Selected 11 projects in 10 states to receive up to $13 million to design community-scale geothermal heating and cooling projects:

- 6 urban projects
- 4 rural projects
- 1 remote project

Coalitions include:

- Community voice
- Workforce
- Analysis/design
- Deployment

energy.gov/eere/geothermal/community-geothermal-heating-and-cooling-design-and-deployment

COMMUNITY GEO
U.S. Department of Energy

Lithium Quantification Report

Salton Sea, California, with box highlighting location Salton Sea Geothermal Field

Funded Lawrence Berkeley National Lab to:

- **Quantify the amount of lithium** in the subsurface at the Salton Sea geothermal area
- **Understand the mechanism(s)** behind the lithium resource as well as how quickly it may deplete/replenish over time
- **Understand the potential environmental impacts**, i.e., water and chemical usage, air quality impacts, and induced seismicity
- **Conduct community outreach** to improve local understanding of the lithium resource, its connection with geothermal energy, and potential impacts of extracting lithium.

escholarship.org/uc/item/4x8868mf

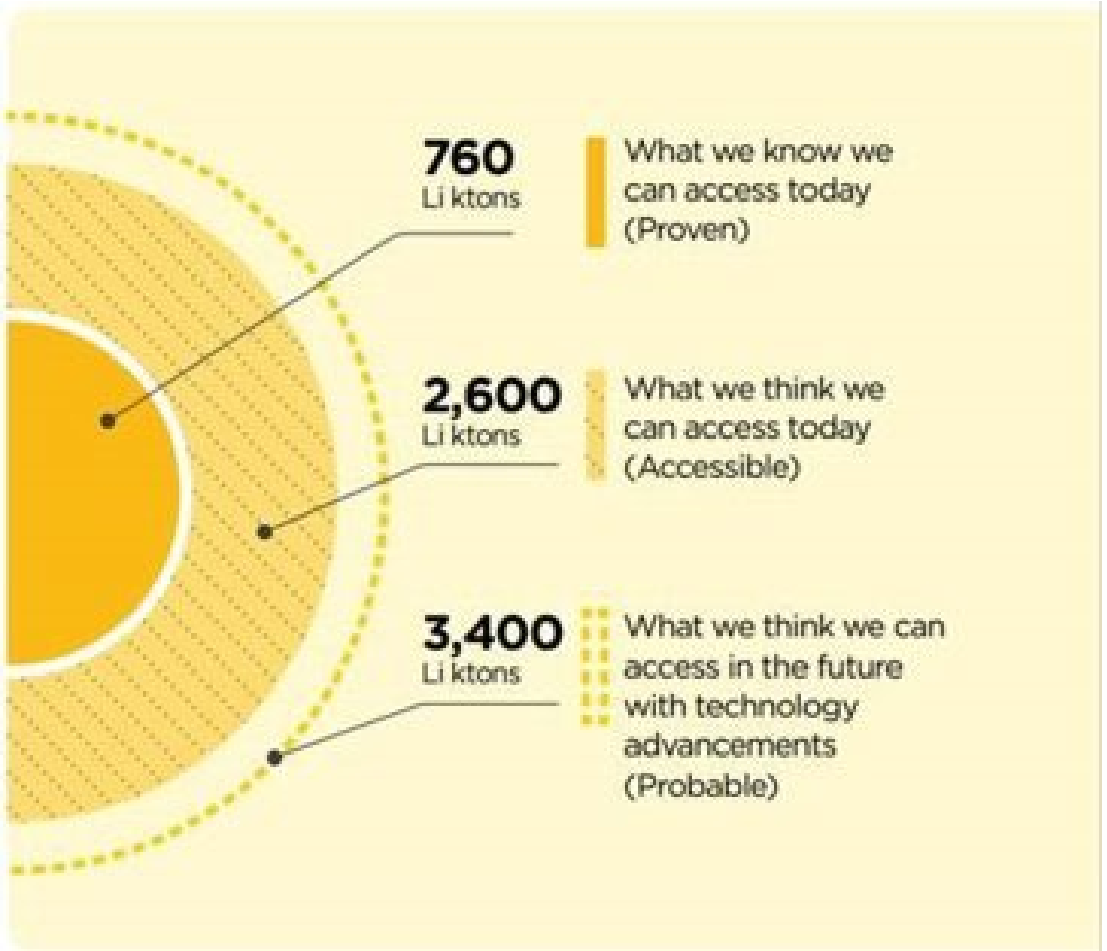
Most comprehensive assessment of lithium resources in the Salton Sea region to date!

Lithium Quantification Report

- Lithium resource in Salton Sea Known Geothermal Resource Area (KGRA) could provide the country with enough secure, domestic lithium to support **more than 375 million electric-vehicle batteries—exceeding all the vehicles currently on U.S. roads.**

- Accessing this resource would enable the United States to **meet or exceed global lithium demand for decades.**

- The Salton Sea region **already produces 400 MW of geothermal** electricity, but the KGRA has potential to produce **up to 2,950 MW**—indicating the opportunity for significant expansion that could be designed to capitalize on the coexisting lithium resource.

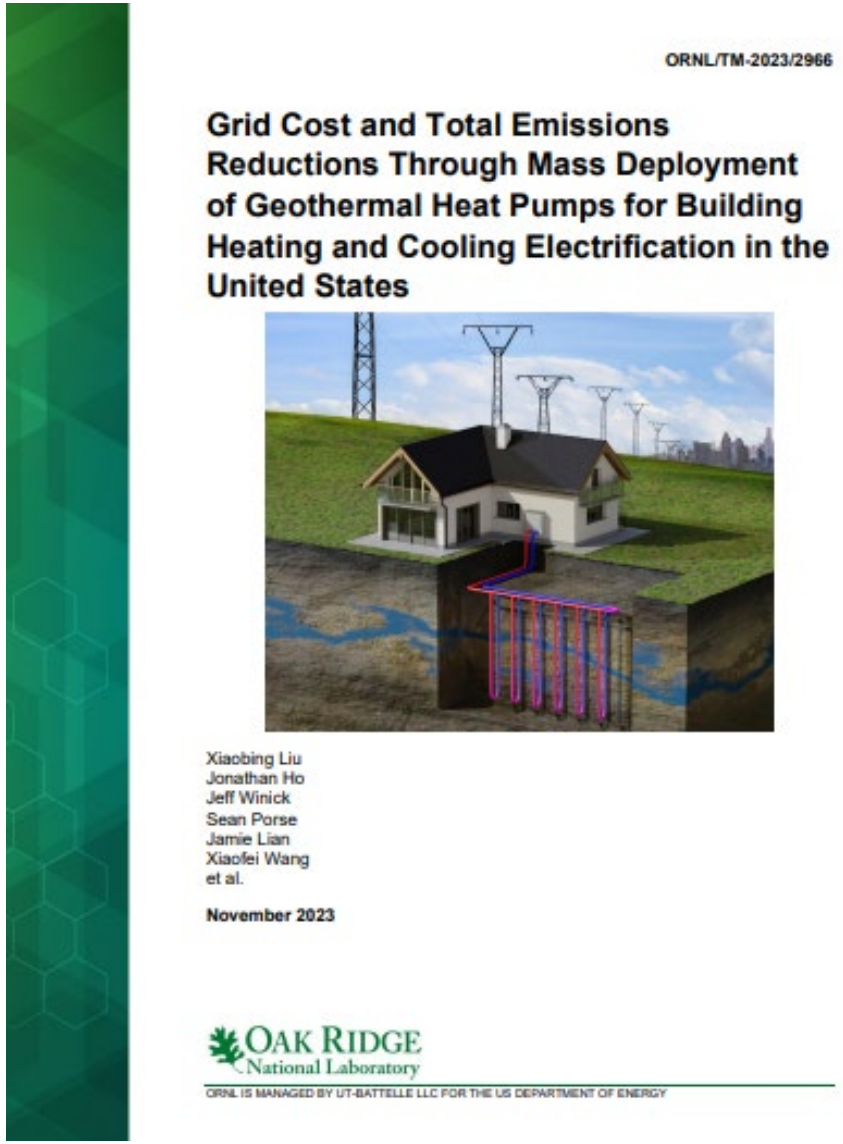


energy.gov/eere/geothermal/lithium

Mass Deployment of Geothermal Heat Pumps

Funded Oak Ridge National Lab and the National Renewable Energy Lab to:

- Project grid- and building-level carbon emissions, cost impacts, and building electricity use that could result from mass deployment of GHPs for building heating and cooling throughout the continental United States
- From that, determine the impacts to the bulk power system under various carbon policy, electrification, and sensitivity scenarios.



ORNL/TM-2023/2966

Grid Cost and Total Emissions Reductions Through Mass Deployment of Geothermal Heat Pumps for Building Heating and Cooling Electrification in the United States

Xiaobing Liu
Jonathan Ho
Jeff Winick
Sean Porse
Jamie Lian
Xiaofei Wang
et al.

November 2023

OAK RIDGE National Laboratory
ORNL IS MANAGED BY UT-BATTELLE LLC FOR THE US DEPARTMENT OF ENERGY

info.ornl.gov/sites/publications/Files/Pub196793.pdf

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Mass Deployment of Geothermal Heat Pumps

Eliminate the need for up to 43,600 miles of new interregional transmission infrastructure – equivalent of up to 44 SunZia transmission projects

Reduce up to 410 GW of nationwide generation capacity requirements – bolstering seasonal US grid resilience

Eliminate more than 7 gigatons of carbon – equivalent to all U.S. emissions produced in 2022

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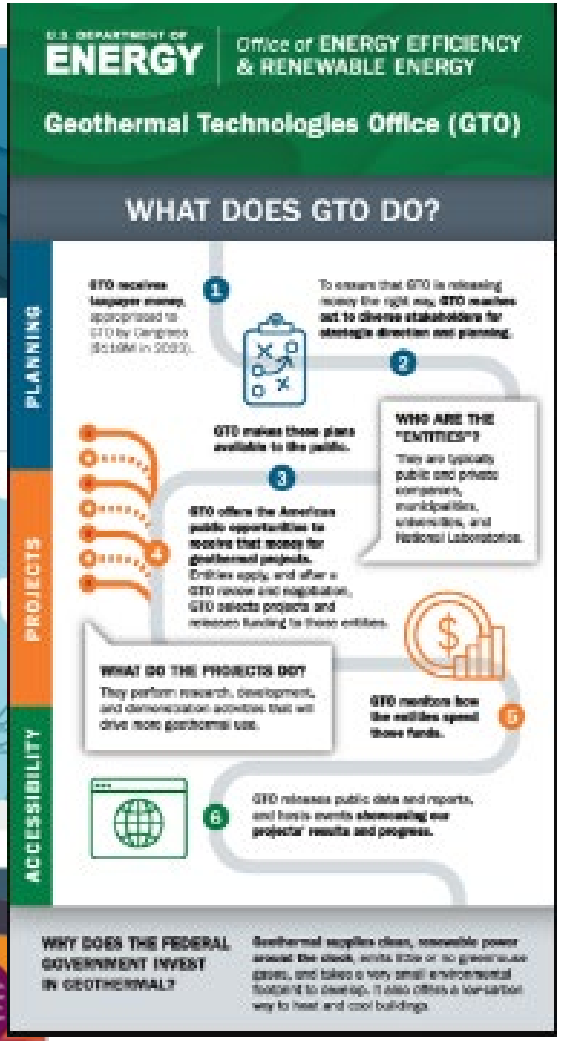
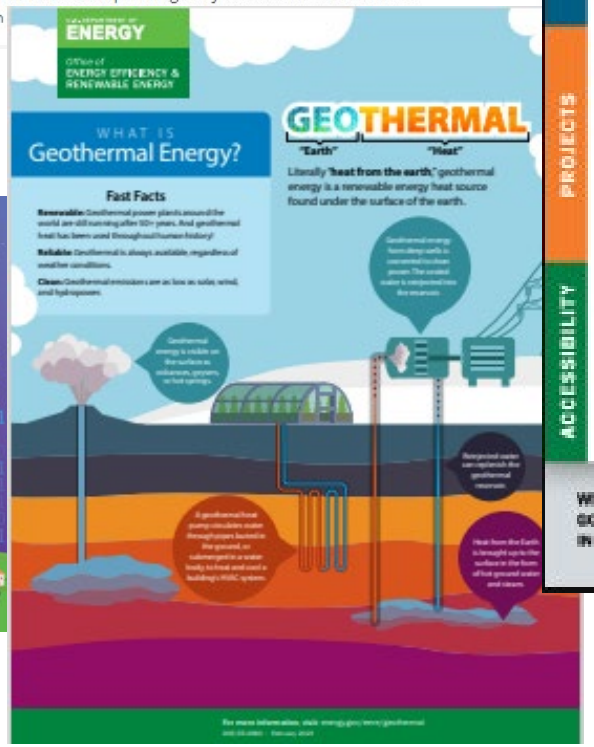
How to Engage with GTO

GTO is using multiple tools and resources to help spread the word about geothermal energy and engage with stakeholders.

- Funding Opportunities
- Updated Website
- Funding Opportunity Quick Guides
- The Drill Down
- Lithium Storymap
- Stakeholder Toolkits
- Infographics
- Project Postcards





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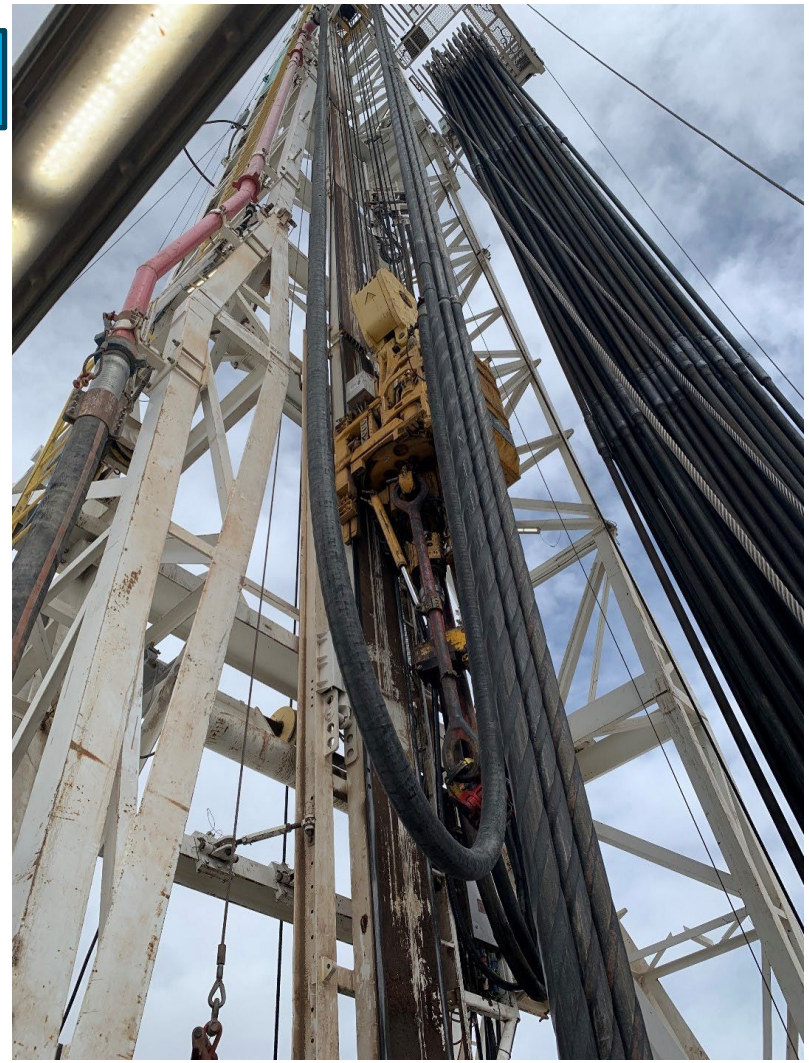
Key Takeaways

NOW is the time to drill for opportunity in geothermal energy!

- Attention at all levels, e.g., Congress, DOE leadership and other offices, media, the public
- More collaboration than ever before
- Projects nationwide to drive innovation, reduce costs, remove non-technical barriers, and engage with stakeholders
- Increasing focus on the need for safe, clean, firm and flexible domestic energy to meet clean energy goals.

GTO looks forward to continuing to work with all of you as we watch geothermal energy become *the* renewable technology of today…and tomorrow!



FORGE drive rig. Courtesy Scott Beautz, National Energy Technology Laboratory

Thank You!

the drill down

Get the hottest geothermal news from *The Drill Down*, GTO's monthly newsletter!
Sign up today: geothermal.energy.gov

Visit GTO at: energy.gov/eere/geothermal or by scanning the QR code.

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

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

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Back Up

Hybrids Research

- Four national laboratory projects to investigate hybridized geothermal power plants through research, analysis, and modeling
  - Hybridization of a geothermal power plant with one or more low-carbon heat sources to increase the generation from new or retrofit geothermal power plants
  - Reservoir thermal energy storage technologies for creating geothermal reservoirs in permeable formations using a low-carbon heat source or low-carbon electricity
- Both topics require robust analyses that help build the case for commercial pathways to hybridizing geothermal power plants.

Aerial view of the Stillwater triple hybrid project (photo courtesy of ENEL Green Power North America, taken from "Better Together: New Synergies and Opportunities From Hybrid Geothermal Projects" by Ann Robertson-Tait and Douglas Hollett via geothermal.org/our-impact/blog/geothermal-hybrid-renewable-systems).

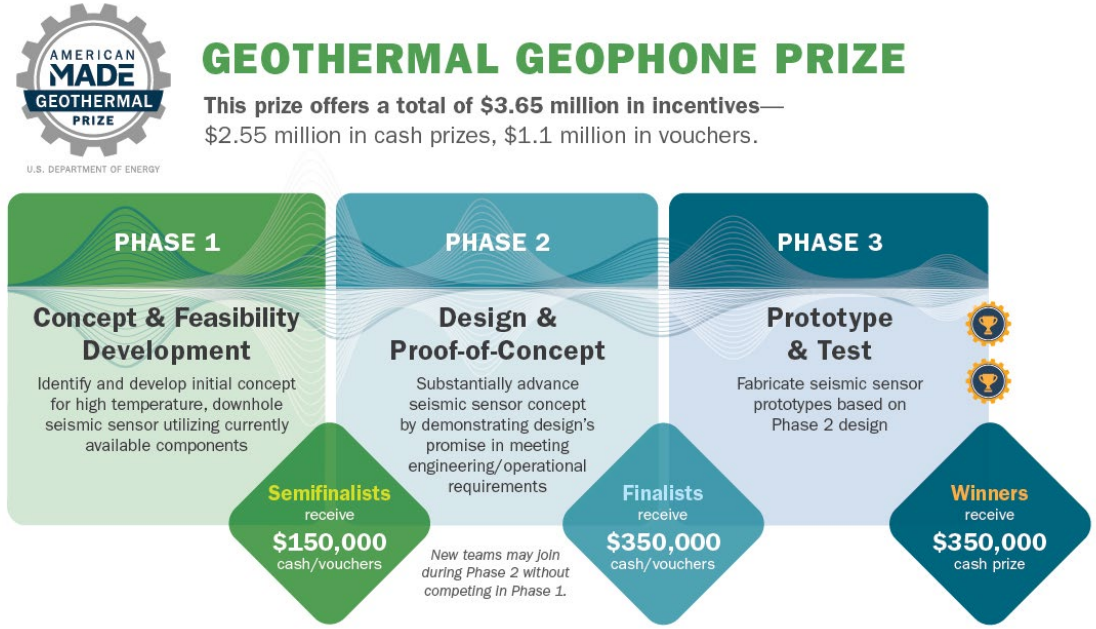
Other EGS Highlights

ReAmplify is providing $8.4 million to establish the commercial viability of geothermal energy production in existing oil and gas wells.

energy.gov/eere/geothermal/wells-opportunity-reamplify

Four ReAmplify projects selected in 2022:

- Geothermix, LLC
- University of Oklahoma
- Transitional Energy
- ICE Thermal Harvesting



Geothermal Geophone Prize

- $3.65 million competition to address the challenges of operating seismic sensors in harsh geothermal environments
- 10 semifinalists in Phase 1
- Phase 2 currently open

americanmadechallenges.org/challenges/geophone/

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Federal Geothermal Partnerships

- GTO and the Federal Energy Management Program are partnering with federal facilities to consider low-temperature geothermal technology to heat and cool installations.
  - Technologies include geothermal heat pumps, district and community heating and cooling systems, and hybrid systems that include geothermal resources.
- Oak Ridge National Laboratory and its partners will develop a technical assistance framework and workflow aimed at a deployment-ready report, supporting the deployment of geothermal energy at federal sites.

Identify federal sites that are strong candidates for geothermal heating and cooling technologies

Provide technical assistance for site characterization/resource confirmation activities at these sites

Break ground for multiple innovative geothermal system deployments

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