

# Geothermal Energy: Drilling for Opportunities

George Stutz, Technology Manager

U.S. Department of Energy Geothermal Technologies Office

January 25, 2023



U.S. DEPARTMENT OF  
**ENERGY**

*Office of*  
**ENERGY EFFICIENCY &  
RENEWABLE ENERGY**





# America's Next Renewable Powerhouse

=



## Electric Power

- **High temperatures (>300°F)**
- Wells up to many thousands of feet deep
- Reliable, flexible, baseload grid power



## Direct Use

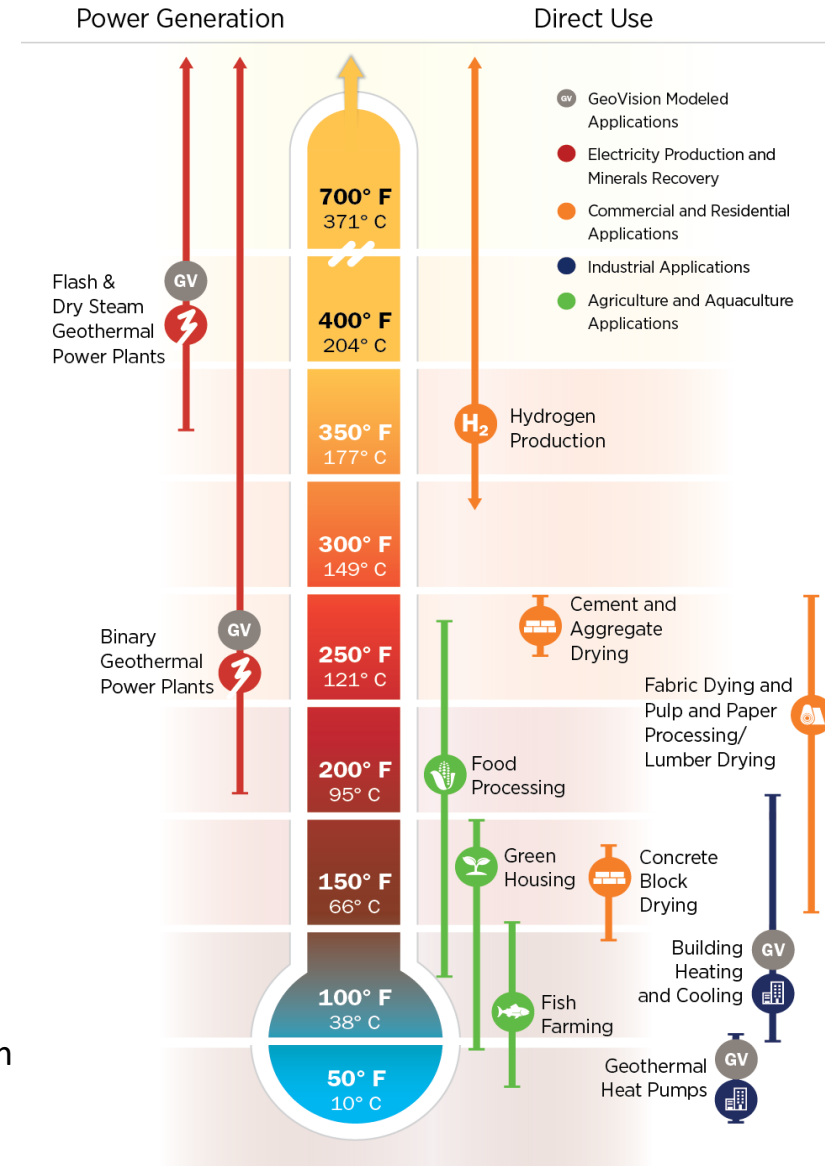
- **Moderate temperatures (80-300°F)**
- Wells hundreds to thousands of feet deep
- Large buildings, agriculture



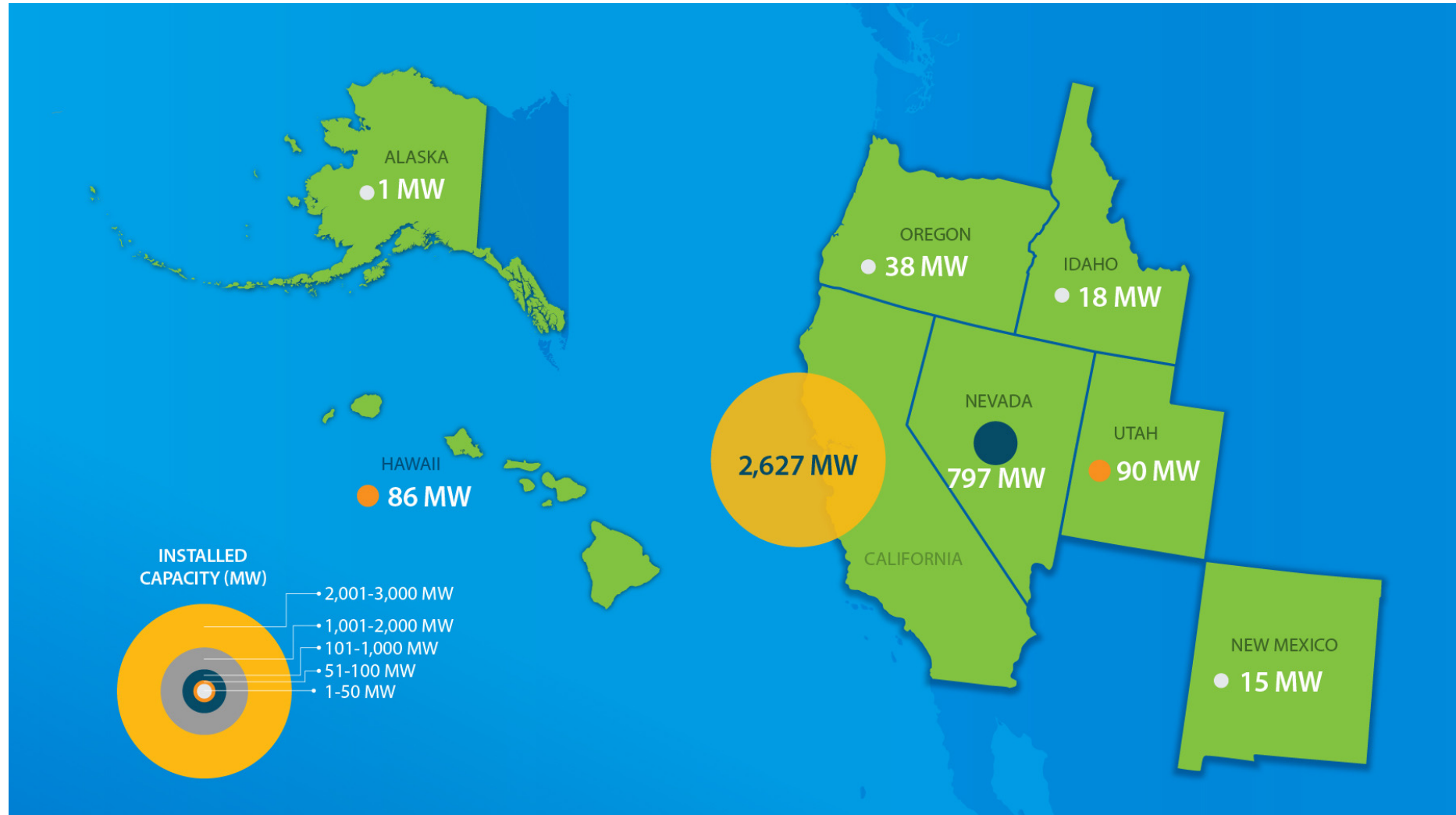
## Heating & Cooling

- **Near-ambient temperatures (40-80°F)**
- Shallow trenches to wells hundreds of feet deep
- Residential, light commercial

*There is a legacy of innovation between geothermal energy and oil and gas.* For instance, DOE research and investment led to development of the **polycrystalline diamond compact drill bit**, a game-changing technology that has delivered more than **\$15 billion in cost savings**—primarily in the oil and gas industry—since 1982.



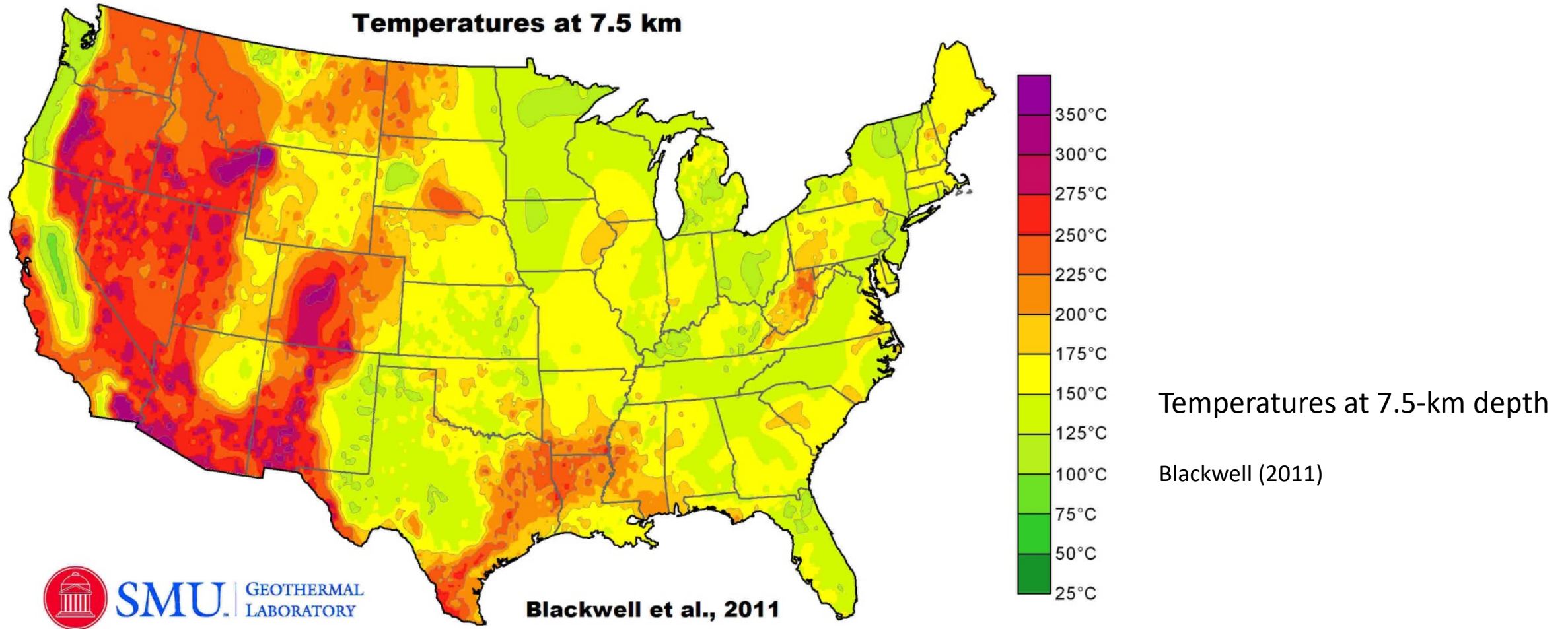
# Geothermal Deployment: Power (Domestic)







# Geothermal Potential: Power (Domestic)



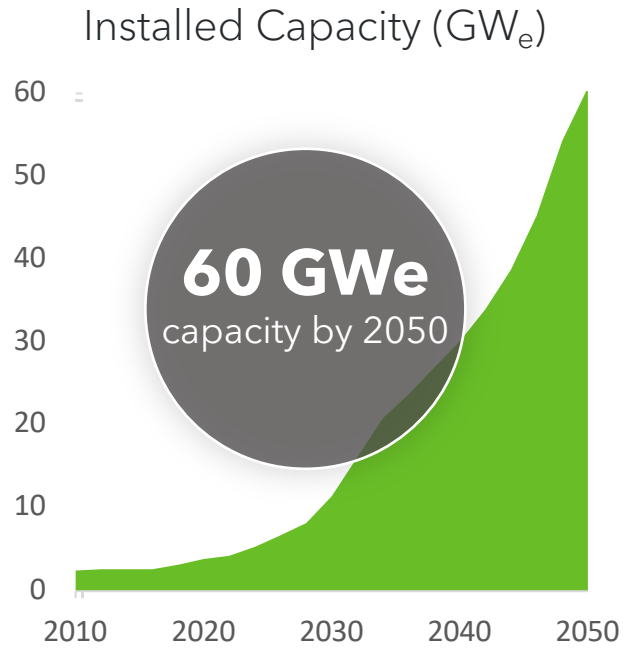
Southern Methodist University Temperature-at-Depth Maps  
[smu.edu/Dedman/Academics/Departments/Earth-Sciences/Research/GeothermalLab/DataMaps/TemperatureMaps](http://smu.edu/Dedman/Academics/Departments/Earth-Sciences/Research/GeothermalLab/DataMaps/TemperatureMaps)



# Geothermal Can Do Big Things


## **ELECTRIC**

 **8.5%** of all U.S. generation by 2050

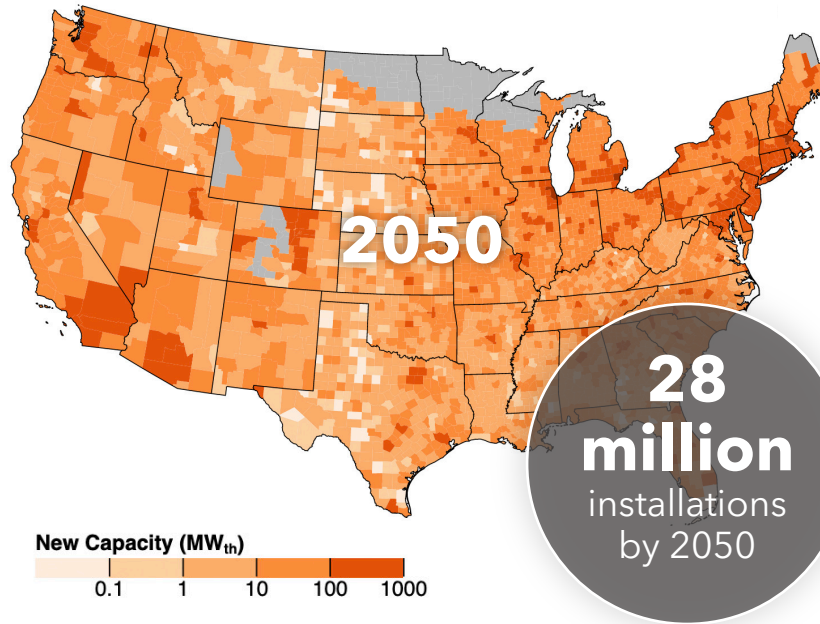


Source: Augustine et al. 2019

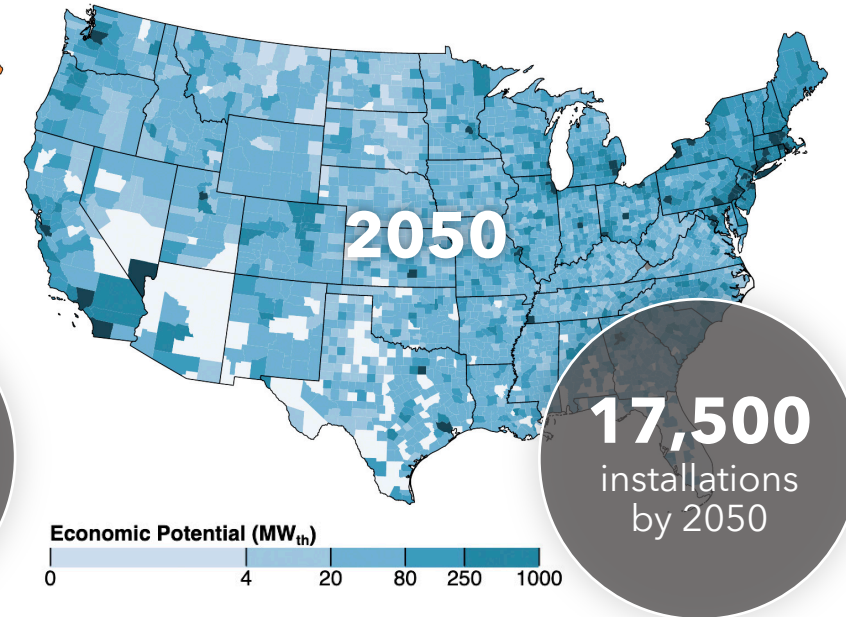
## **HEATING & COOLING**

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

### Geothermal Heat Pumps



### District Heating



 up to **516 MMT**  
of avoided CO<sub>2</sub>e

 up to **1,281 MMT**  
of avoided CO<sub>2</sub>e

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



# Geothermal Barriers

## Key Technical Barriers

### DEEP

Thousands of feet in the subsurface (4,000 to > 10,000 for EGS)



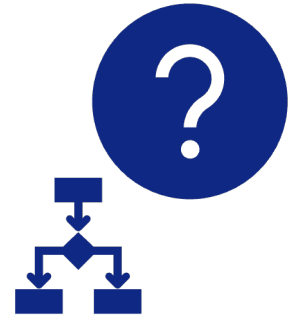
### EXTREME

Hot, hard, abrasive rock, corrosive conditions



### UNKNOWN

- Lack of data
- Lack of models necessary to approximate the subsurface



## Non-Technical Barriers

- Permitting and land access
- Development timelines
- Lack of public awareness and understanding
- Inadequate market valuation



# 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 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

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

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



## HYDROTHERMAL RESOURCES

Aims to increase exploration and confirmation success rates, and to accelerate the identification and use of undiscovered geothermal resources in the United States.



## ENHANCED GEOTHERMAL SYSTEMS

Works to advance EGS, with particular focus on reservoir characterization, enhancement, and sustainability.

# Wells of Opportunity (WOO) ReAmplify



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



# Wells of Opportunity (WOO) ReAmplify



Principal Investigator	Project
Geothermix, LLC	Will conduct a field demonstration in the Austin Chalk in Texas to demonstrate use of thermoelectric generators that can use low-quality, currently wasted heat to produce commercial quantities of electrical power to be used locally or transmitted to the grid with a near-zero carbon footprint
University of Oklahoma	Will evaluate and demonstrate the viability of geothermal production (minimum 1 MW) from an Oklahoma hydrocarbon field, providing energy for two facilities using innovative injection and production well patterns and data-driven smart well completion technologies
Transitional Energy	Aims to generate at least 1 MW from existing O&G wells in Blackburn Hills, Nevada, through a pilot that will roadmap co-production and oil field transition; project includes hourly production data and findings and a transition roadmap for oilfield workers.
ICE Thermal Harvesting	Will characterize 11 wells to evaluate thermal energy available for harvesting from produced fluids from the Elk Hills field near Bakersfield, California; will install, commission, and optimize ICE's heat-to-power electrical generation package and develop plan to scale across basins





# Drilling Demonstrations Campaign

Geothermal Technologies Office

**Announcing a New Funding Opportunity**

DOE invests **\$20 million** in innovative technology to lower the costs of **Geothermal Drilling**

U.S. DEPARTMENT OF ENERGY Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

**TO GET THE UNITED STATES  
TO 100% CLEAN ELECTRICITY  
BY 2035**

Alejandro Moreno  
Dep. Asst. Secretary  
Renewable Power, DOE

## Drilling Technology Demonstrations (Up to \$20M)

- Will reduce the 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, Colorado) – Occidental Petroleum and partners from industry, national laboratories, and academia
  - **Evaluation of Physics-Based Drilling and Alternative Bit Design** (The Geysers Geothermal Field, California) – Geysers Power Company and partners from industry, national laboratories, and academia



# Leveraging Oil and Gas for Geothermal

- The Geothermal Energy from Oil and gas Demonstrated Engineering ([GEODE](#)) funding opportunity will establish a consortium to leverage oil & gas subsurface assets, technologies, and expertise to help solve geothermal energy's toughest challenges, while providing clean energy employment opportunities and environmental benefits for communities.
- The initial funding opportunity will form the consortium, develop a strategy, and establish an organizational framework to transition oil and gas best practices into geothermal.
- In future years, subject to appropriations, GEODE will invest up to \$155 million to release periodic competitive solicitations for analysis, RD&D, and workforce efforts.

U.S. DEPARTMENT OF ENERGY

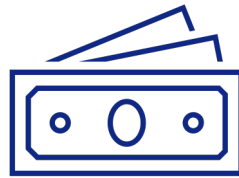


Geothermal Energy from Oil and gas  
Demonstrated Engineering

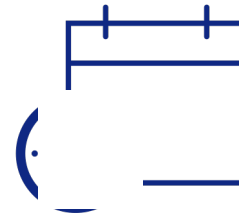
# Enhanced Geothermal Shot



Reduce the cost of enhanced geothermal system electricity  
to \$45/MWh by 2035



**\$ 45/MWh**



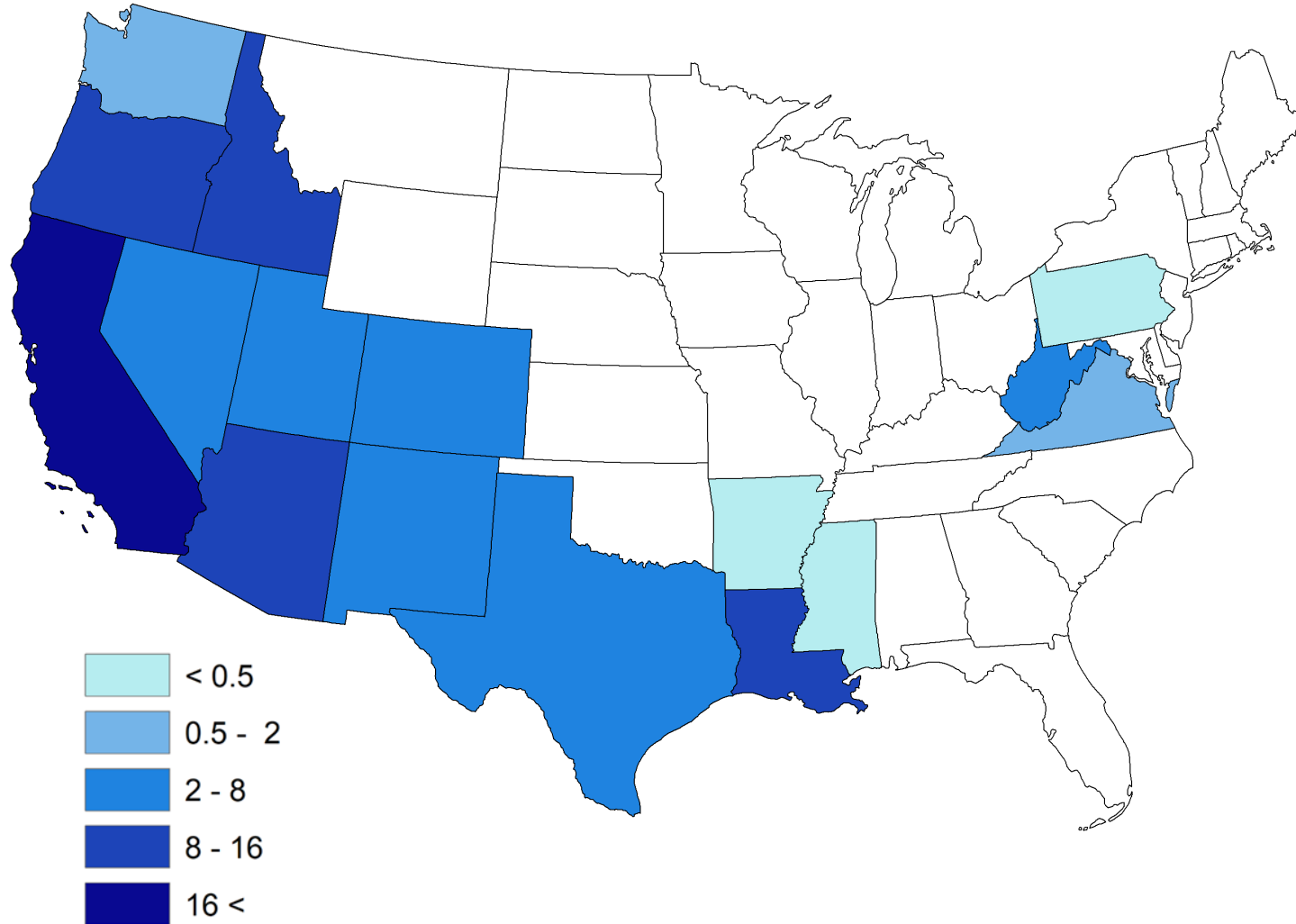
**2035**





# Enhanced Geothermal Shot: Benefits

## 2050 Deep EGS Deployment Capacity (GW)



**Nationwide expansion of EGS for power**



**Clean heating & cooling for millions of U.S. households**



**Drives just transition and leverages fossil fuel workers**



# Geothermal Permitting



**Optimizing permitting timelines alone could increase installed geothermal electricity-generation capacity to 13 GWe by 2050.**

- Federal interagency task force to address geothermal permitting timelines.
- Will provide recommendations directed toward federal agency regulators, California and Nevada state regulators, the National Renewable Energy Coordination Office, and relevant Congressional Committees



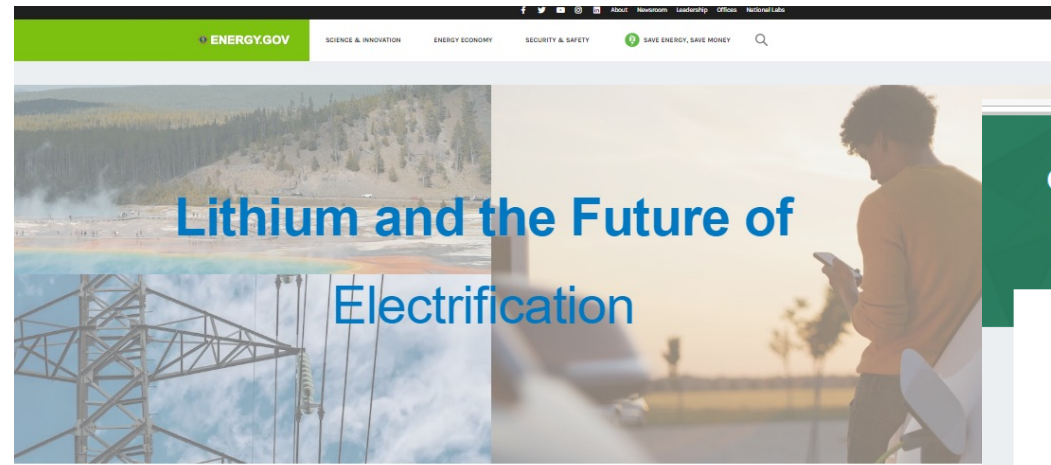




# How to Engage with GTO

**GTO uses multiple tools and resources to help communicate funding opportunities, provide education about geothermal energy, and engage with stakeholders.**

- Funding Opps Webpage
- Lithium Storymap
- Updated Website
- Stakeholder Toolkits
- Infographics
- Project Postcards
- Funding Opportunity Quick Guides
- The Drill Down Newsletter
- Eblasts



# Thank You!



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

*Sign up today:*

[geothermal.energy.gov](http://geothermal.energy.gov)



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

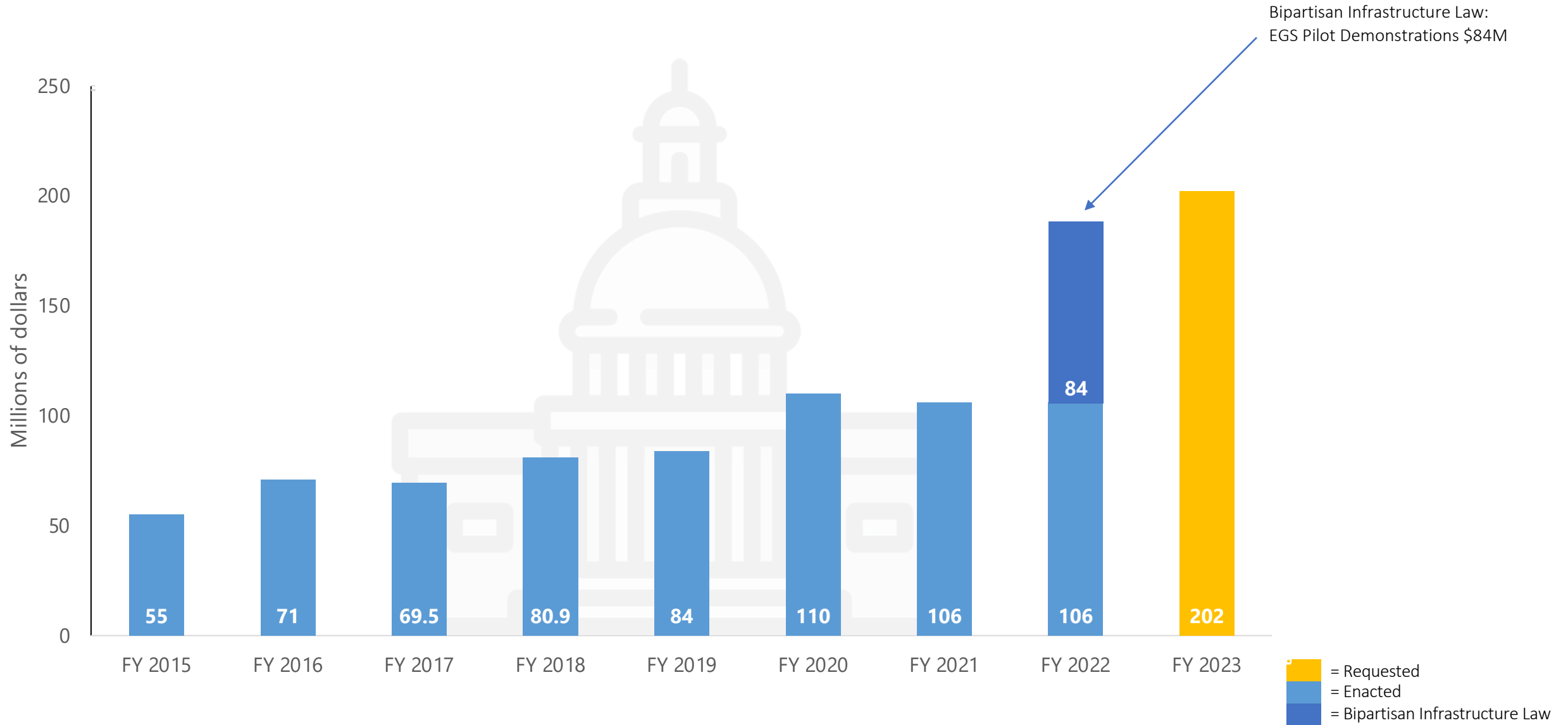
*Send us your resume or CV:*

[doe.geothermal@ee.doe.gov](mailto:doe.geothermal@ee.doe.gov)

# Back Up



# GTO FY 2022 Budget: Update



# Geothermal in the Bipartisan Infrastructure Law

## SEC. 41007. Enhanced Geothermal Systems Demonstrations (\$84M)

- Four demonstration projects, different geologic settings, potentially commercially viable locations
- For power production or direct use (heating/cooling)
- At least one east of the Mississippi River
- Topic Areas:
  - **Topic 1:** *EGS Proximal Demonstrations*
  - **Topic 2:** *EGS Green Field Demonstrations*
  - **Topic 3:** *Super-hot / Supercritical EGS Demonstrations*
  - **Topic 4:** *Eastern U.S. EGS Demonstrations*



In April, GTO released a **Request for Information (RFI)** to solicit feedback from industry, academia, research laboratories, government agencies, and other stakeholders on demonstration project attributes and outcomes that will most likely lead to successful EGS deployment in the future.

**Funding Opportunity to be released this winter.**

# Geothermal in the Inflation Reduction Act

- The Inflation Reduction Act (IRA) has numerous provisions that include geothermal.
  - The IRA's many provisions include lowering energy costs—saving families \$500 per year on energy bills—and tackling the climate crisis.
  - The IRA **extends the investment tax credit (ITC)** and the production tax credit (PTC) for renewables including geothermal, through 2024.
  - The IRA also provides a **30 percent tax credit, up to \$2,000**, for purchase of a heat pump (geothermal or air source).



The Inflation Reduction Act of 2022, H.R. 5376

