

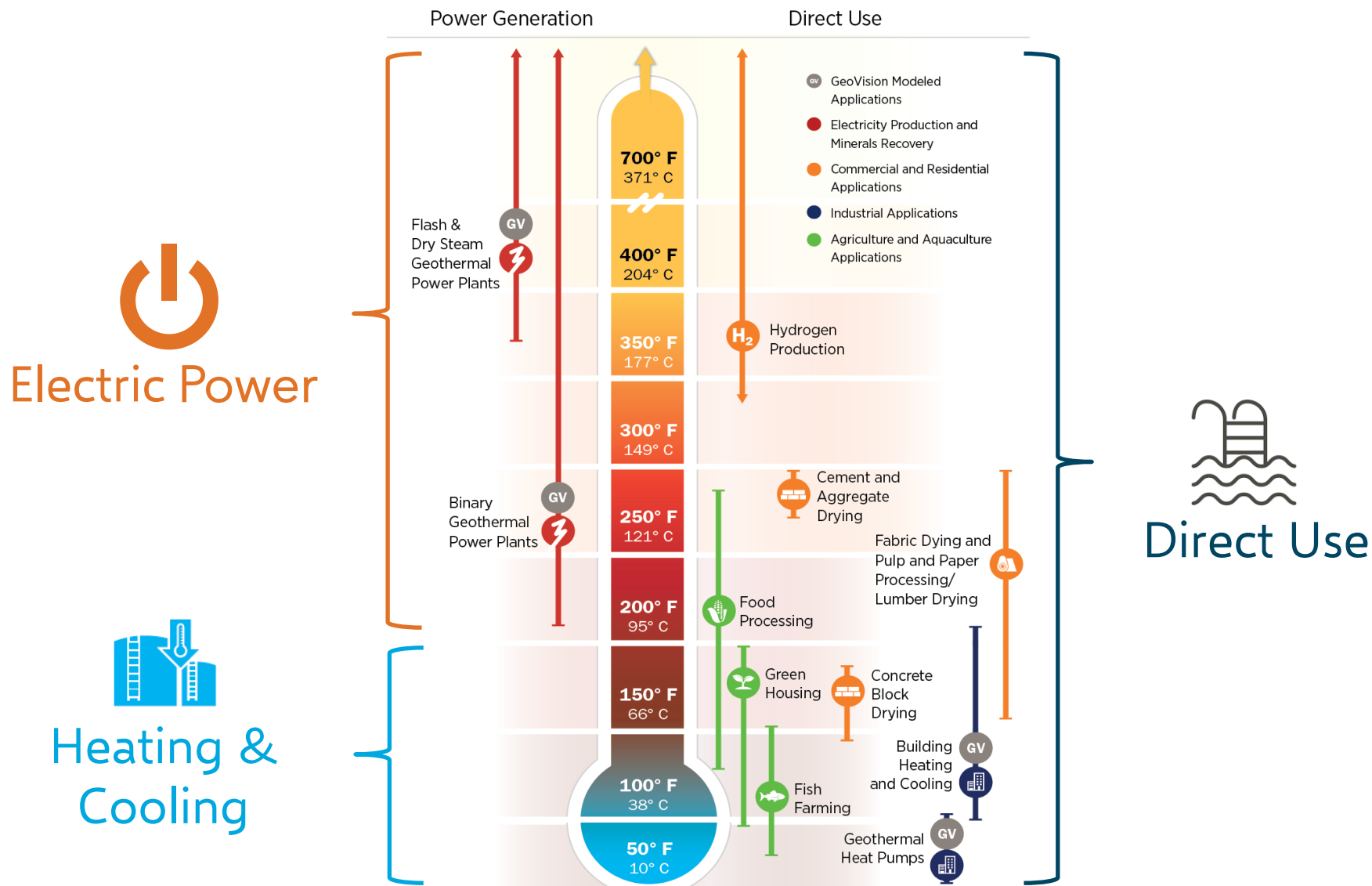
# **Geothermal Energy:** *Solutions for a Zero-Emissions Sustainable Energy Future*

Dr. Susan Hamm  
Office Director  
Geothermal Technologies Office  
U.S. Department of Energy



# Geothermal Energy

## America's Next Renewable Powerhouse



# Geothermal Energy

*America's Next Renewable Powerhouse*

**Geothermal energy is at the core of a just and equitable transition to a zero-emissions sustainable energy future.**

- Carbon-free renewable energy
- Efficient heating and cooling
- Thousands of valuable energy sector jobs
- Opportunities for negatively impacted energy communities
- Improves grid stability
- Potential domestic supply of critical materials



# Carbon-free Renewable Energy

## Biden/Harris Administration Climate Goals

- ✓ Net-zero-emissions power sector by 2035
- ✓ Economy-wide net-zero emissions no later than 2050



Electric sector

- up to 516 MMT of avoided CO<sub>2</sub>e
- 8% of ALL U.S. generation by 2050



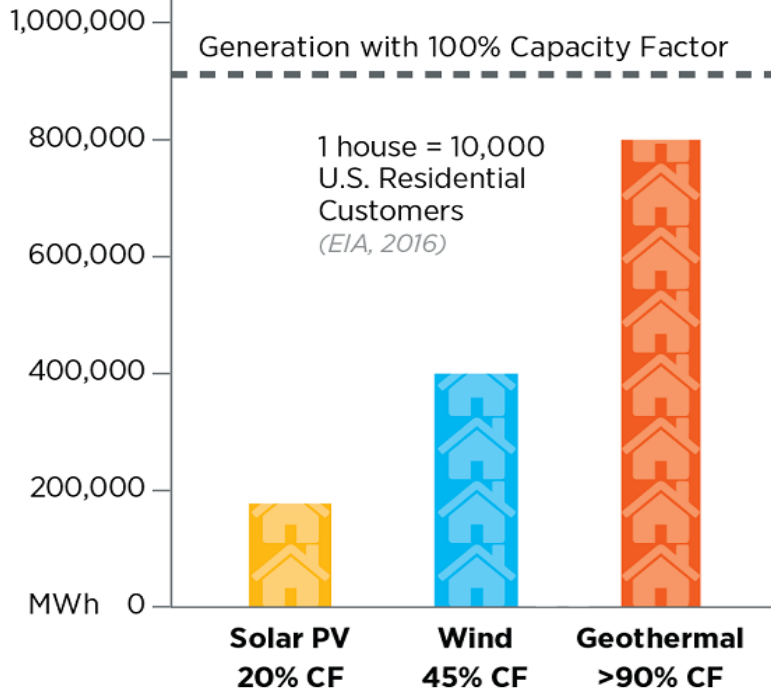
Heating & cooling sector

- up to 1,281 MMT of avoided CO<sub>2</sub>e
- 23% of U.S. & market by 2050

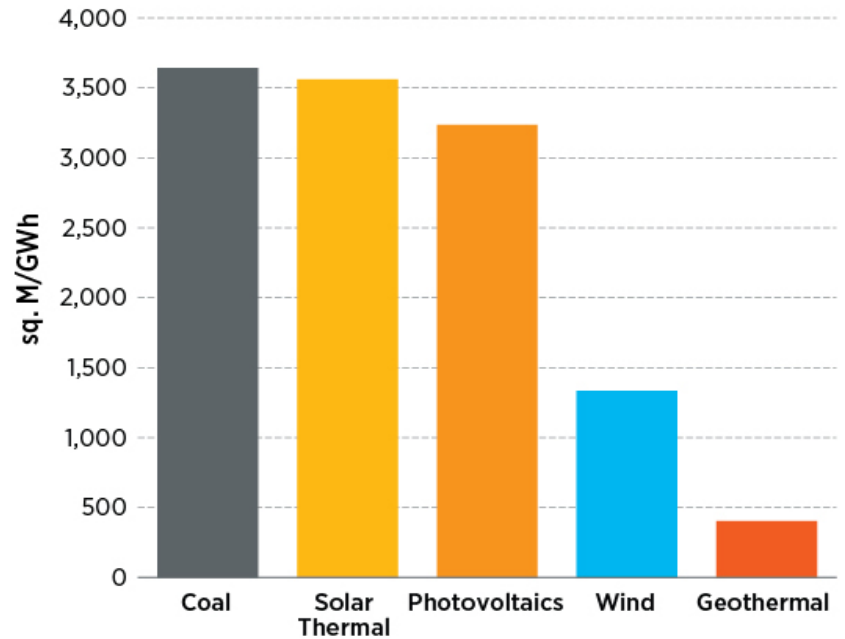
Emissions Reductions = removal of 26 million cars per year

# Carbon-free Renewable Energy

A geothermal plant will generate 2-4 times as much electricity as a wind or solar plant of the same capacity due to its high capacity factor (CF)



Geothermal is a remarkably efficient, space-saving source of power, with a physical footprint far smaller than other energy sources.



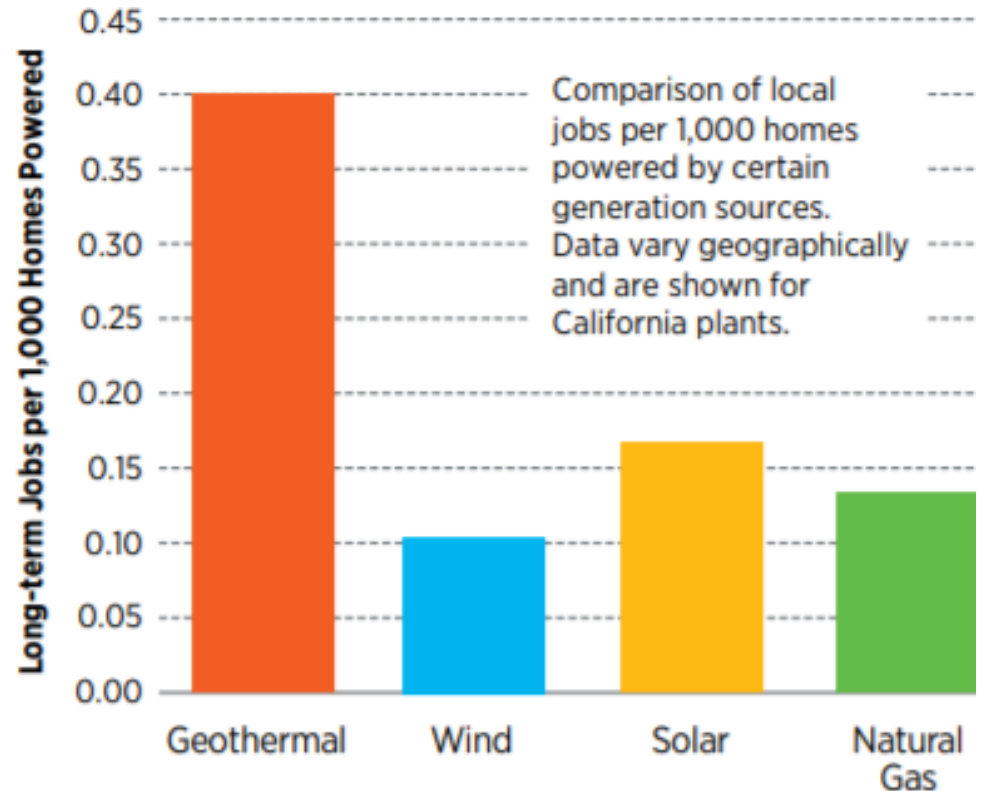
Geothermal power plants provide valuable flexibility to integrated grid systems. High capacity factor enables optimal baseload energy output.

# Valuable Clean Energy Sector Jobs



At a local level, geothermal power plants can provide 2x the long-term jobs per powered household vs other utility-scale power-generation technologies

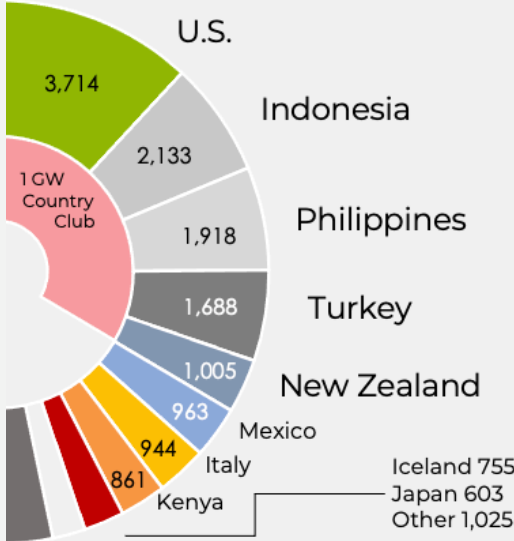
- ✓ 262,000 "gross" full-time jobs in 2048 from Power Production
- ✓ + 36,660 "gross" jobs at from Geothermal Heat Pumps in 2044



# Geothermal Deployment: Power

## Worldwide Geothermal Growth:

With development in close to 50 additional countries, global generation capacity could reach 28,000 MW in the next 15-20 years



## ThinkGeoEnergy Top 10 Geothermal Countries 2020

Installed Capacity in MWe  
Year-End 2020

**Total 15,608 MW**



Source: ThinkGeoEnergy Research (2021)



# Priorities for the Office of Energy Efficiency and Renewable Energy



## EERE Guiding Principles

Accelerate the research, development, demonstration, and deployment (RDD&D) of innovative technologies that will transition Americans to a 100% clean energy economy no later than 2050 and ensure the clean energy economy benefits all Americans.

### Keys to Ensure the Greatest Impact



Environmental Justice & Equity



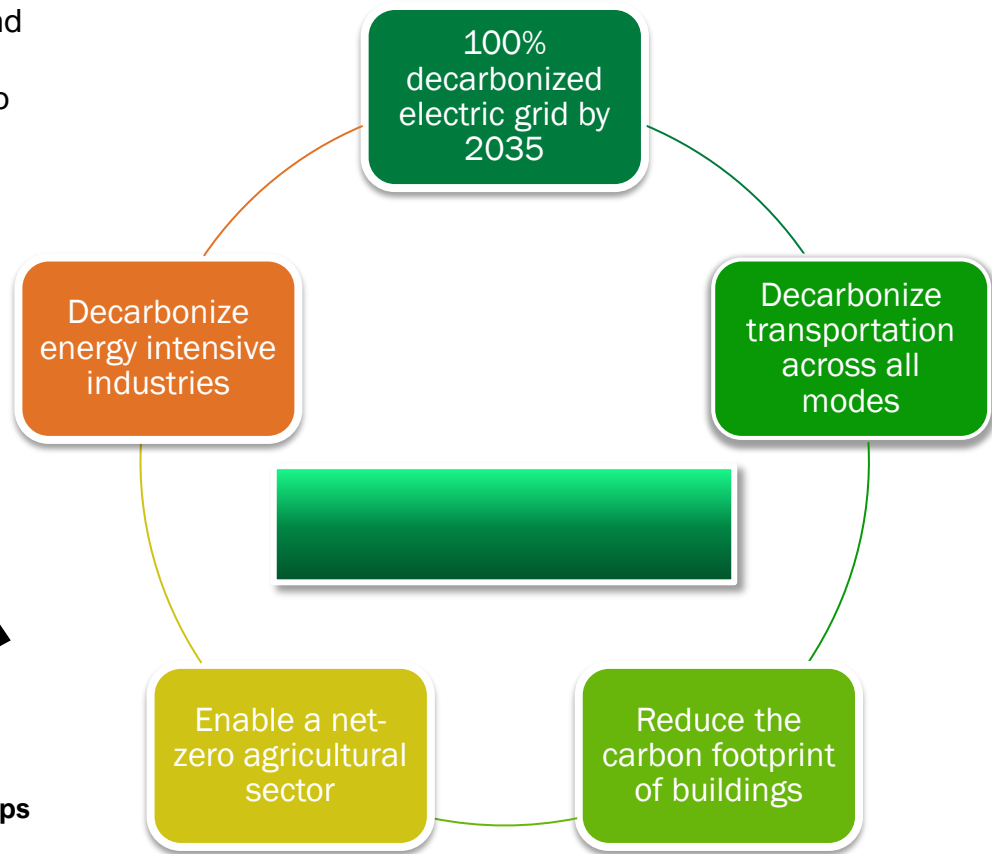
Diversity in STEM



Workforce Development



State & Local Partnerships





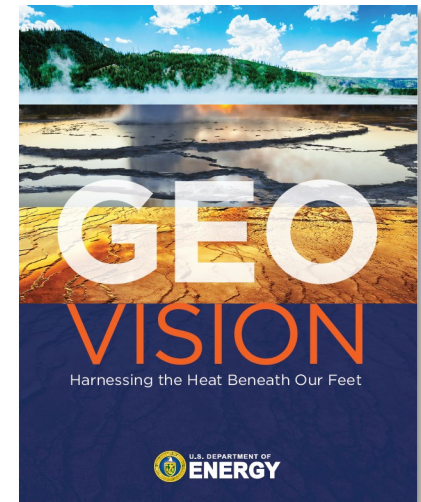
# Priorities for the Geothermal Technologies Office

Geothermal Technologies Office (GTO) works to increase deployment of geothermal energy through research, development, and demonstration of innovative technologies.

## Top Priorities

GTO's top priority is to **demonstrate geothermal energy's value as the dispatchable baseload renewable of the future** for U.S. To do this, we will support R&D to:

- Drive toward a clean, carbon-free electricity grid by supplying 8.5% of total U.S. generation through 60 GW of EGS and hydrothermal resource deployment.
- Decarbonize building heating and cooling loads by capturing the economic potential for 17,500 geothermal district heating (GDH) installations and by installing geothermal heat pumps (GHPs) in 28 million households nationwide.
- Inspire economic, environmental, and social justice advancements through increased geothermal technology deployment.



# What are the challenges GTO wants to address?

## Challenges

- **Drilling costs** are high - wells can cost \$10-15M or more
- **Exploration risk** - identifying and quantifying "hidden" resources
- **Understanding the subsurface** to make it work in our favor
- Developing technology to **create permeability** in the subsurface where we need it and keep fractures open over time
- **Permitting issues** - NEPA permitting up to 6-8 times per project
- **Public awareness** is low for geothermal in both electric and heating/cooling sectors

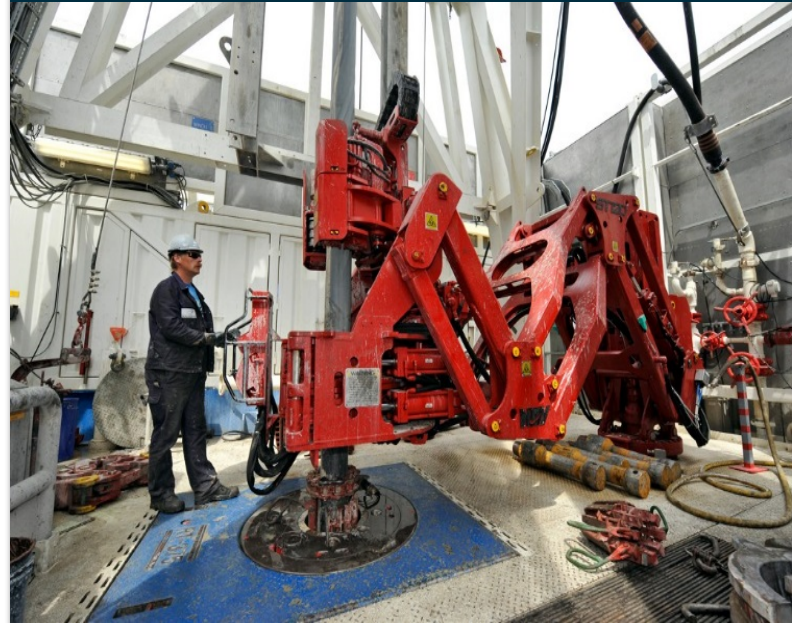
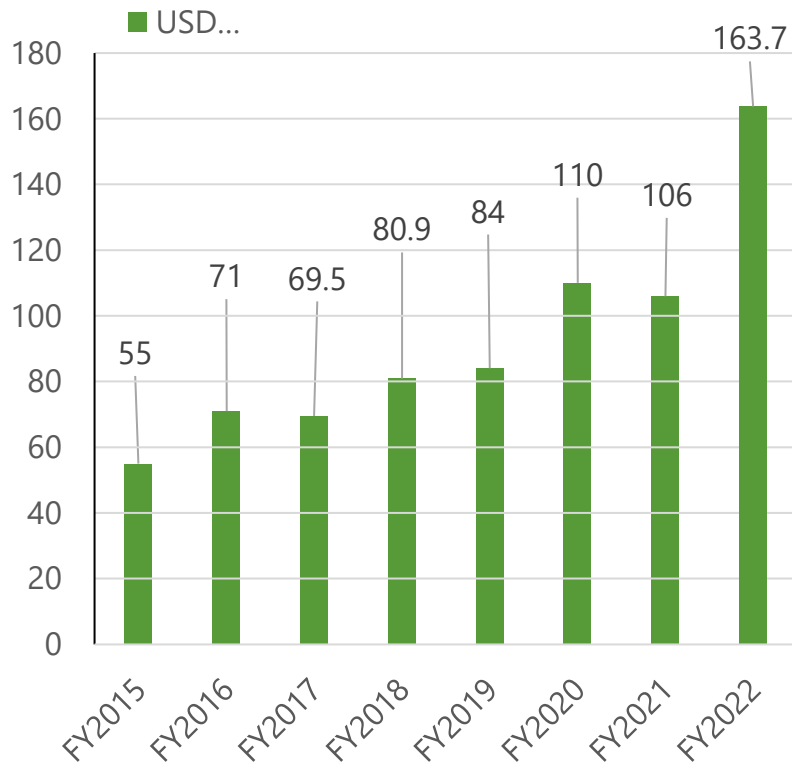


Photo: Baker Hughes

# GTO Budget and Programs

GTO has seen large increases in RD&D budgets, culminating in an FY 2022 budget request that is a 200% increase over FY 2015.

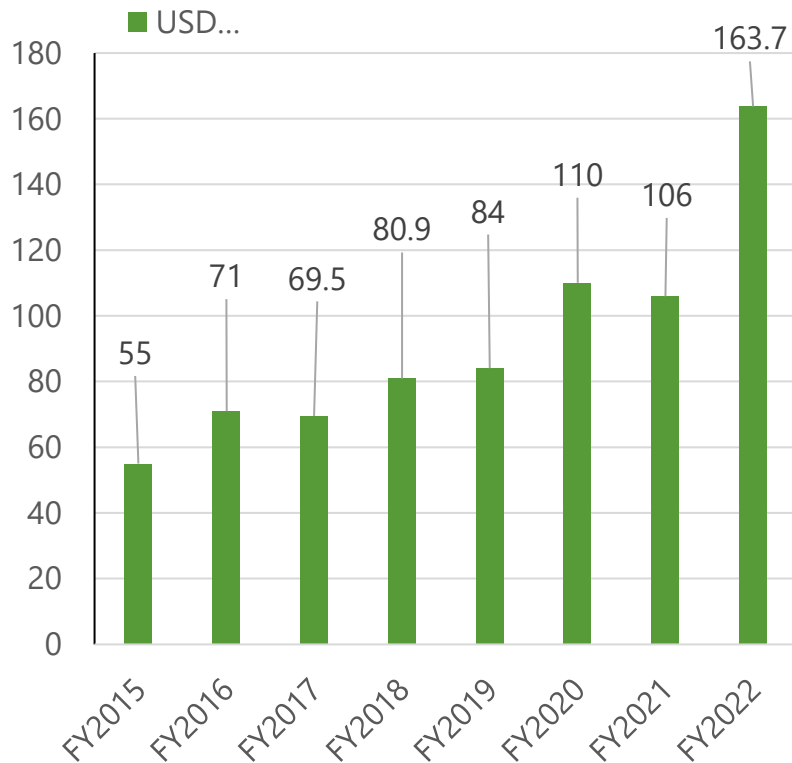


## GTO RD&D Programs in FY 2020-2021 (a sampling)

- American-Made Challenges
  - Geothermal Lithium Extraction Prize
  - Geothermal Manufacturing Prize
- Efficient Drilling for Geothermal Energy (EDGE)
- EGS Collab
- EGS Hydraulic Properties FOA
- EGS Wells of Opportunity FOA
  - Pilot (FORGE Test Wells)
  - Amplify (EGS Near-Field RD&D)
  - ReAmplify (Using existing hydrocarbon fields)
- Energy Storage Grand Challenge
  - Deep Direct Use Demonstrations
  - Reservoir Thermal Energy Storage Research
- Federal Installation Partnerships
- Frontier Observatory for Research in Geothermal Energy (FORGE)
- GeoDAWN (Geoscience Data Acquisition for Western Nevada) – partnership with USGS
- Geothermal Collegiate Competition
- Geothermal Market Report
- Hidden Geothermal Systems in the Basin and Range
- Machine Learning for Geothermal Energy
- Zonal Isolation for Geothermal Drilling

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# FY 2021 Enhanced Geothermal Systems (EGS) FOAs

## Hydraulic Properties

Federal Funding: \$12,000,000

Recipient Cost Share: 20%

- This FOA is specifically focused on the development of novel technologies and techniques that can be used to **control flow regimes outside of the wellbore**, within the reservoir, and to mitigate undesirable flow and heat transfer rates that degrade the performance of EGS reservoirs.
- **FOA Release** – April 30, 2021
- **Full Apps Due** – June 15, 2021

## Wells of Opportunity

Federal Funding: \$14,500,000

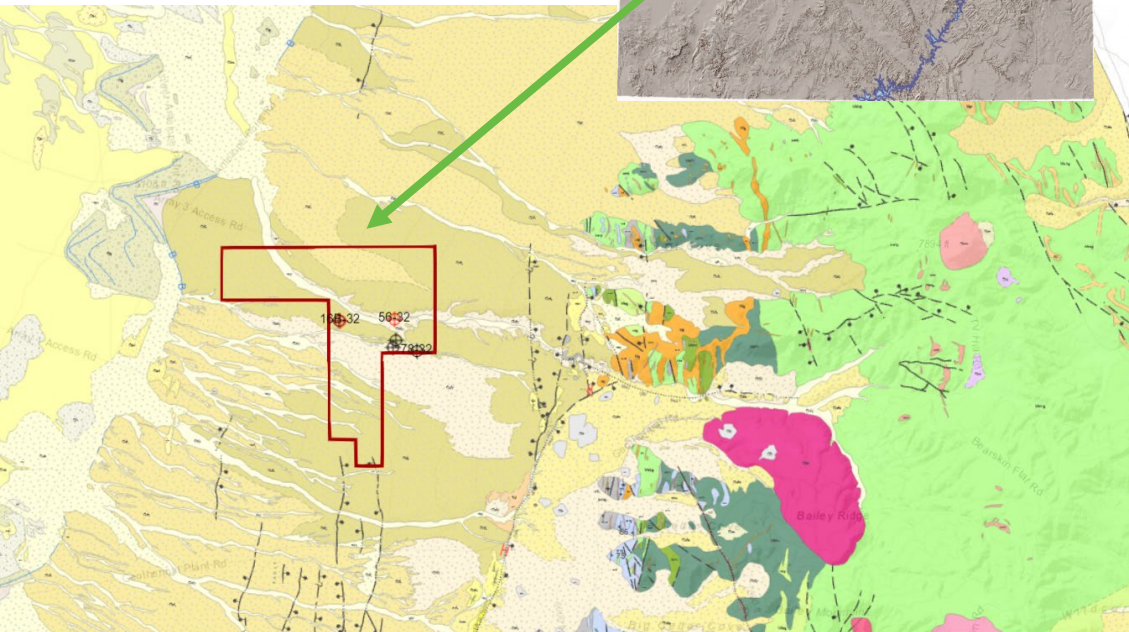
Recipient Cost Share: 20%

- **Amplify**: EGS field validation effort culminating in **new power production**, illustrating that near-field EGS can be successfully deployed now and that low permeability/unproductive wells near existing hydrothermal fields can be turned into valuable assets.
- **ReAmplify**: establish a pilot program where the production of **geothermal heat from existing hydrocarbon fields** can be demonstrated for electricity production or direct use applications.
- **FOA Release** – June 10, 2021
- **Full Apps Due** – July 28, 2021



# Frontier Observatory for Research in Geothermal Energy (FORGE)

- The FORGE site in Milford, Utah is a field laboratory for testing ideas and methods to make enhanced geothermal system (EGS) a commercial reality.



## FORGE PRINCIPLES

- Gain fundamental understanding of the **key mechanisms** controlling Enhanced Geothermal System (EGS) success.
- **Develop, test, and improve** new technologies and techniques in an ideal EGS environment.
- Make integrated **comparison of technologies and tools** in a controlled environment.
- Rapidly **disseminate technical data and communicate** to the research community, developers, and other interested parties



Photo by U of U

# FORGE Project Selections for FY 2020 R&D Solicitation

Prime Awardee	Project Title
<b>1 – Zonal Isolation</b>	
Welltec	Development of a Smart Completion & Stimulation Solution
Petroquip Energy Services, LLC	Zonal Isolation Solution for Geothermal Wells
Colorado School of Mines	Development of Multi-Stage Fracturing System and Wellbore Tractor to Enable Zonal Isolation During Stimulation and EGS Operations in Horizontal Wellbores
<b>2 - Stress Parameters</b>	
Battelle Memorial Institute	Battelle - FORGE Topic 2
Lawrence Livermore National Laboratory	Closing the Loop Between In-Situ Stress Complexity and EGS Fracture Complexity
The University of Oklahoma	Application of Advanced Techniques for Determination of Reservoir-Scale Stress State at FORGE
<b>3 – Field-Scale Characterization</b>	
Clemson University	A Strain Sensing Array to Characterize Deformation at the FORGE Site
Stanford University	Wellbore Fracture Imaging Using Inflow Detection Measurements
Lawrence Berkeley National Laboratory	Joint Electromagnetic/Seismic/InSAR Imaging of Spatial-Temporal Fracture Growth and Estimation of Physical Fracture Properties During EGS Resource Development
Rice University	Fiber-Optic Geophysical Monitoring of Reservoir Evolution at the FORGE Milford Site

# FORGE Project Selections for FY 2020 R&D Solicitation

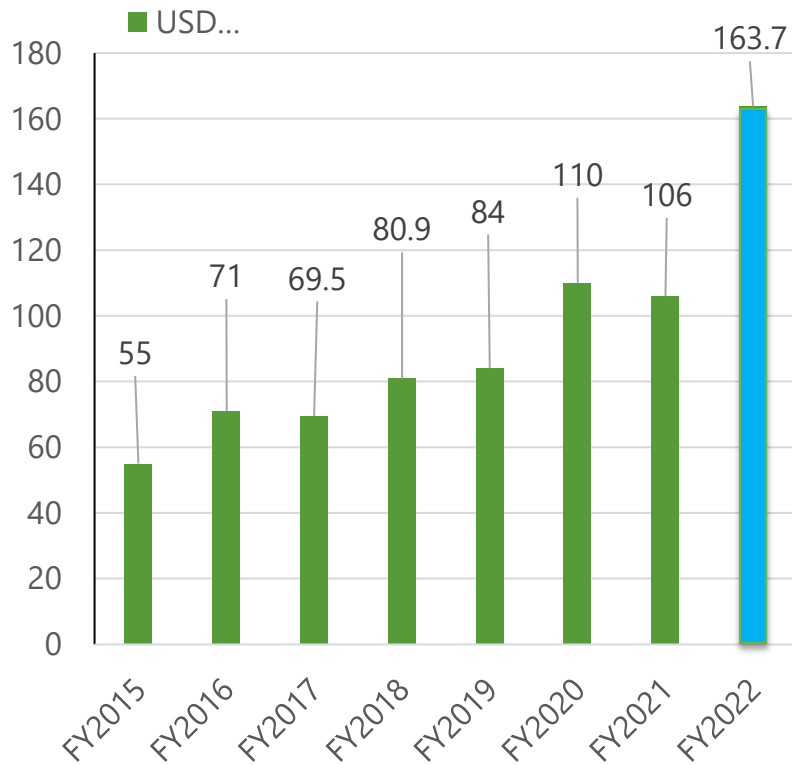
Prime Awardee	Project Title
<b>4- Well Stimulation</b>	
Fervo Energy Company	Optimization and validation of a plug-and perf stimulation treatment design at FORGE
The University of Texas at Austin	Design and Implementation of Innovative Stimulation Treatments to Maximize Energy Recovery Efficiency at the Utah Forge Site
<b>5 – Laboratory and Modeling Studies</b>	
Pennsylvania State University	Seismicity-Permeability Relationships Probed Via Nonlinear Acoustic Imaging
Lawrence Livermore National Laboratory	Coupled Investigation of Fracture Permeability Impact on Reservoir Stress and Seismic Slip Behavior
U.S. Geological Survey	Evolution of Permeability and Strength Recovery of Shear Fractures under Hydrothermal Conditions
The University of Oklahoma	Experimental Determination, and Modeling-Informed Analysis of Thermo-Poromechanical Response of Fractured Rock for Application to FORGE
Purdue University	Role of Fluid and Temperature in Fracture Mechanics and Coupled THMC Processes for Enhanced Geothermal Systems

**Next FORGE R&D solicitation expected FY 2022**



# GTO Budget and Programs

GTO has seen large increases in RD&D budgets, culminating in an FY 2022 budget request that is a 200% increase over FY 2015.



To read the GTO Budget Justification:

[www.energy.gov/cfo/articles/fy-2022-budget-justification](http://www.energy.gov/cfo/articles/fy-2022-budget-justification)

# FY 2022 Budget Request Highlights



## Frontier Observatory in Research in Geothermal Energy (FORGE) (\$20M)

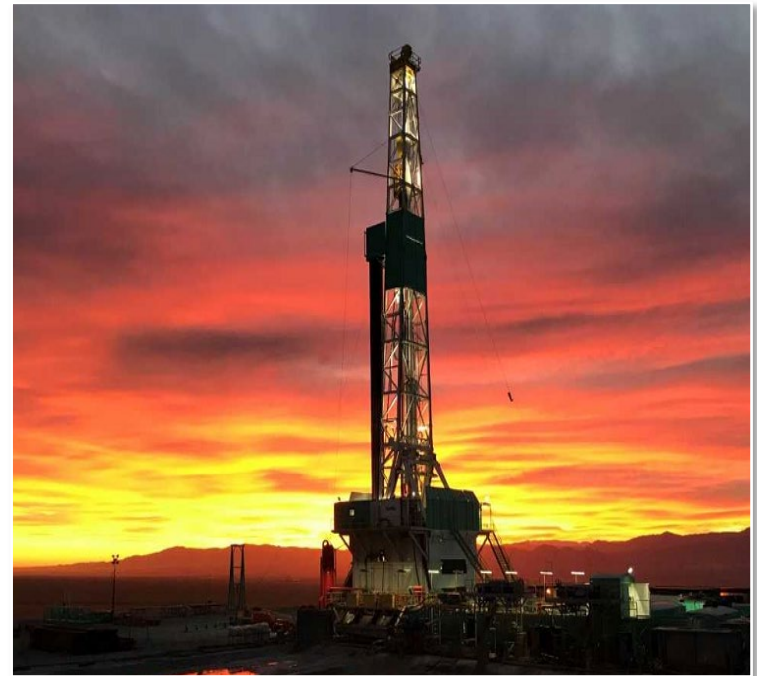
Utah FORGE drilled the first-ever highly deviated geothermal well at a rate twice the industry standard. In FY 2022, GTO will support the next R&D solicitation, contributing to meeting Administration goals for a carbon-free electric grid.

## Drilling Technology Demonstration Campaign (\$20M)

This campaign will enable field demonstration to prove utility and efficacy to industry and attract future private investment and use to further the Nation's goal to a 100 percent clean energy economy.

## Geothermal Energy from Oil and gas Demonstrated Engineering (GEODE) (\$10M)

This is a new consortium designed to leverage the oil & gas subsurface industry to help solve geothermal energy's toughest challenges.



Shown here is a drilling rig at the FORGE site outside of Milford, Utah. RD&D at FORGE continues through 2024 and will drive technological advances in enhanced geothermal systems. Photo: Eric Larson / FORGE Utah

# FY 2022 Budget Request Highlights: GEODE



Photo Credit: Bridget Ayling, UNR

## Hydrocarbons to Heat

Shifting and revitalizing existing skills and infrastructure to utilize an abundant, sustainable carbon-free subsurface commodity (the heat beneath our feet).

The Oil & Gas Industry is primed to contribute technologies, wells, and workforce to our Nation's transition to baseload geothermal power.



Over 100,000+ O&G workers were laid off in 2020<sup>1</sup>

1. <https://www.forbes.com/sites/energyinnovation/2020/09/21/plugging-abandoned-wells-the-green-new-deal-jobs-plan-republicans-and-democrats-love/?sh=6440924f2e10>

# FY 2022 Budget Request Highlights



## Community Geothermal Heating & Cooling Technical Assistance & Deployment (\$15M)

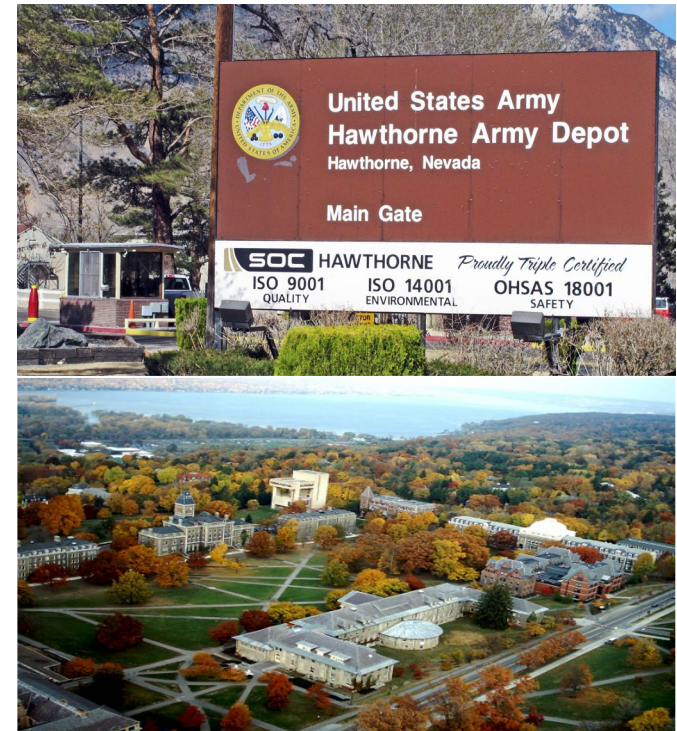
This initiative funds technical assistance to demonstrate, deploy, and implement community-scale direct use geothermal district energy systems through installation of geothermal heat pumps (GHP) and/or direct use of geothermal fluids.

## Federal Partnerships for Geothermal Installations (\$5.4M)

GTO and FEMP will make it possible for Federal agencies (DOD, GSA, State, NASA, DOE Labs, Park Service) to consider geothermal energy to heat/cool (and in some limited cases, potentially power) their installations.

## Next Generation Connected Communities (\$5M)

GTO will collaborate with the Building Technologies Office to demonstrate the market viability of highly energy-efficient, demand-flexible, low-carbon buildings integrated with distributed energy resources (DERs) to reliably and cost-effectively contribute to America's transition to a zero-carbon grid.



Military installations and university campuses are among the variety of locations that can benefit from direct use geothermal. Shown here are the Hawthorne Army Depot in Nevada and Cornell University in New York.

# Thank you!

## The Drill Down



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

Sign up today:  
[geothermal.energy.gov](mailto: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)