

The Future of Enhanced Geothermal Systems in the United States

Lauren Boyd, Senior Advisor – Geothermal Technologies Office

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Geothermal Energy: America's Renewable Powerhouse



Electric Power

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



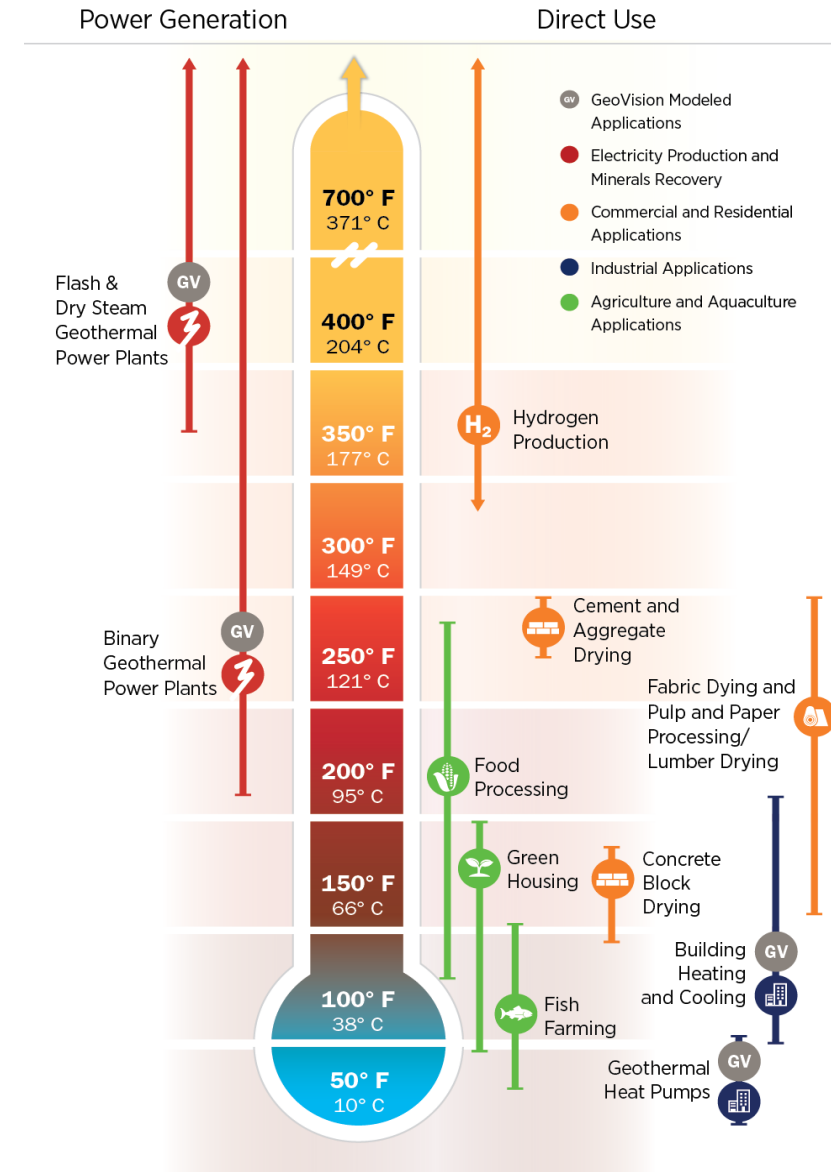
Direct Use

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



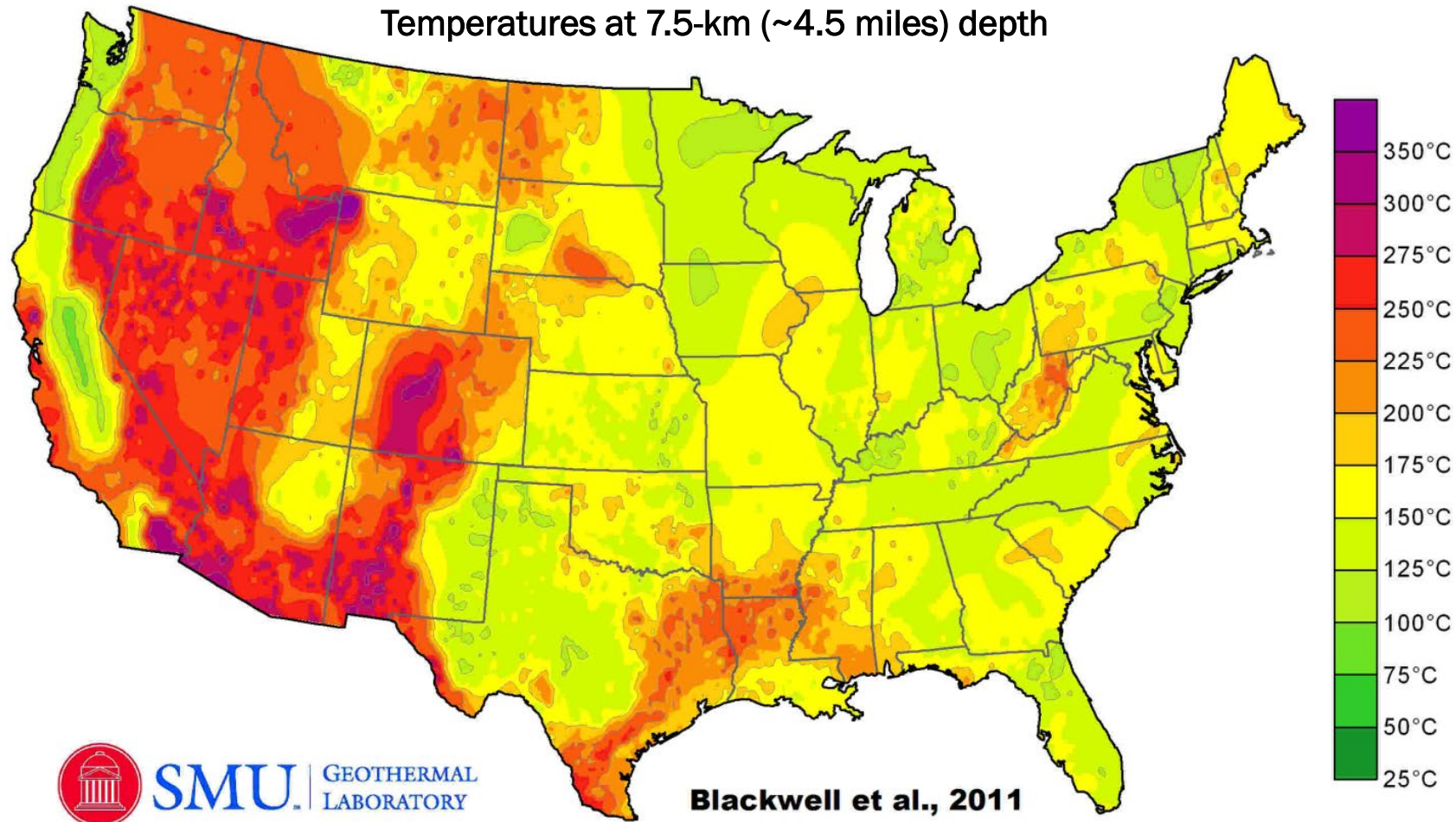
Heating & Cooling

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





The United States is Hot!



5 TWe

heat resource: enough
to power the entire
world!

While these depths are not accessible with existing technology, **there are geothermal resources everywhere in the United States** and innovation will help us reach them!

Southern Methodist University Temperature-at-Depth Maps
smu.edu/Dedman/Academics/Departments/Earth-Sciences/Research/GeothermalLab/DataMaps/TemperatureMaps

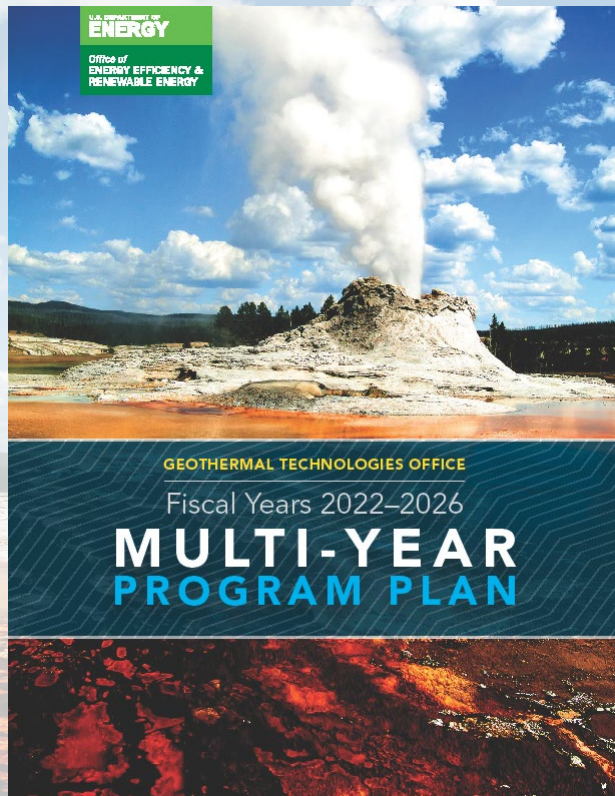
Geothermal Electricity Generation



Geothermal nameplate capacity by state (2021)

2021 Geothermal Market Report [nrel.gov/docs/fy21osti/78291.pdf](https://www.nrel.gov/docs/fy21osti/78291.pdf)

The **Multi-Year Program Plan** is a 5-year plan of activities GTO is pursuing 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>

Total emissions reductions from geothermal could be equal to that of more than **25 million cars** annually!

STRATEGIC GOAL 1

Drive toward a carbon-free electricity grid, with more than 90 GW of geothermal electricity-generating capacity 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 Mission and Program Areas

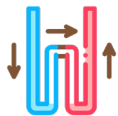
GTO's mission is to increase geothermal energy deployment through research, development, and demonstration of innovative technologies that enhance exploration and production.



Data, Modeling, and Analysis



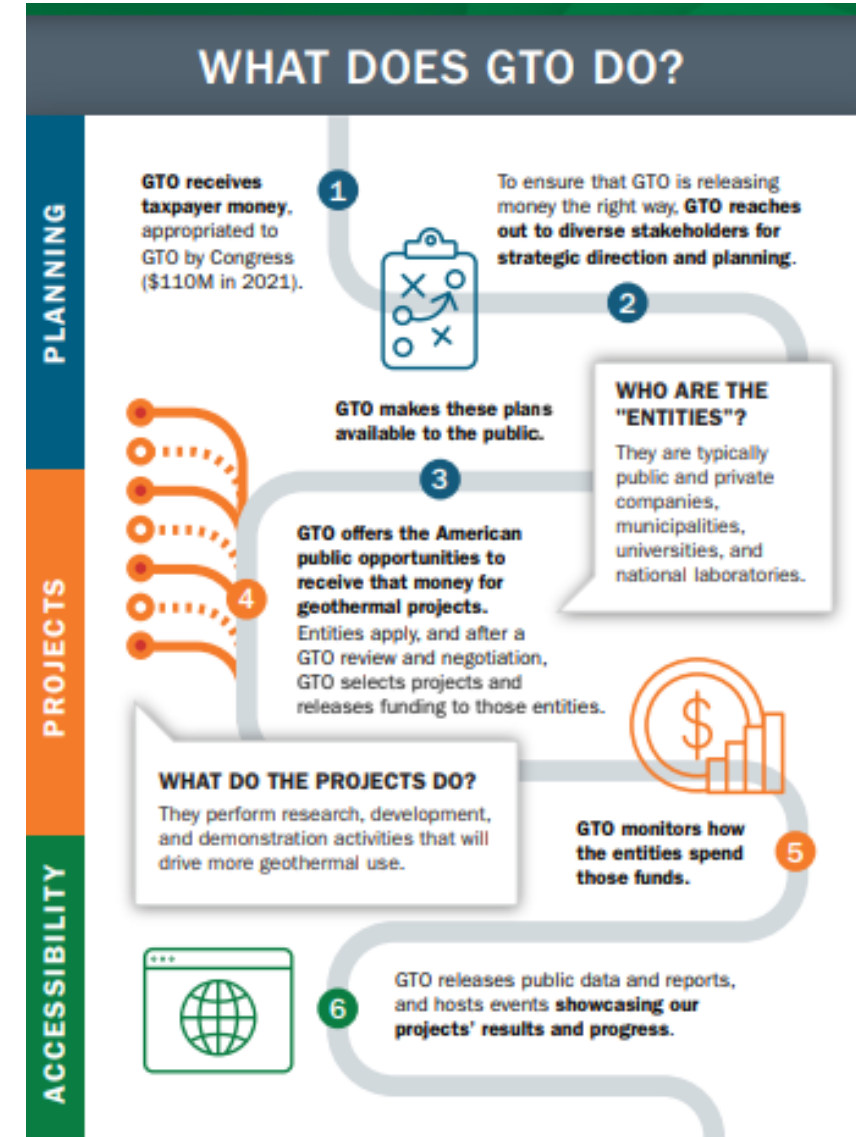
Hydrothermal Resources



Low-Temperature and Coproduced Resources



Enhanced Geothermal Systems



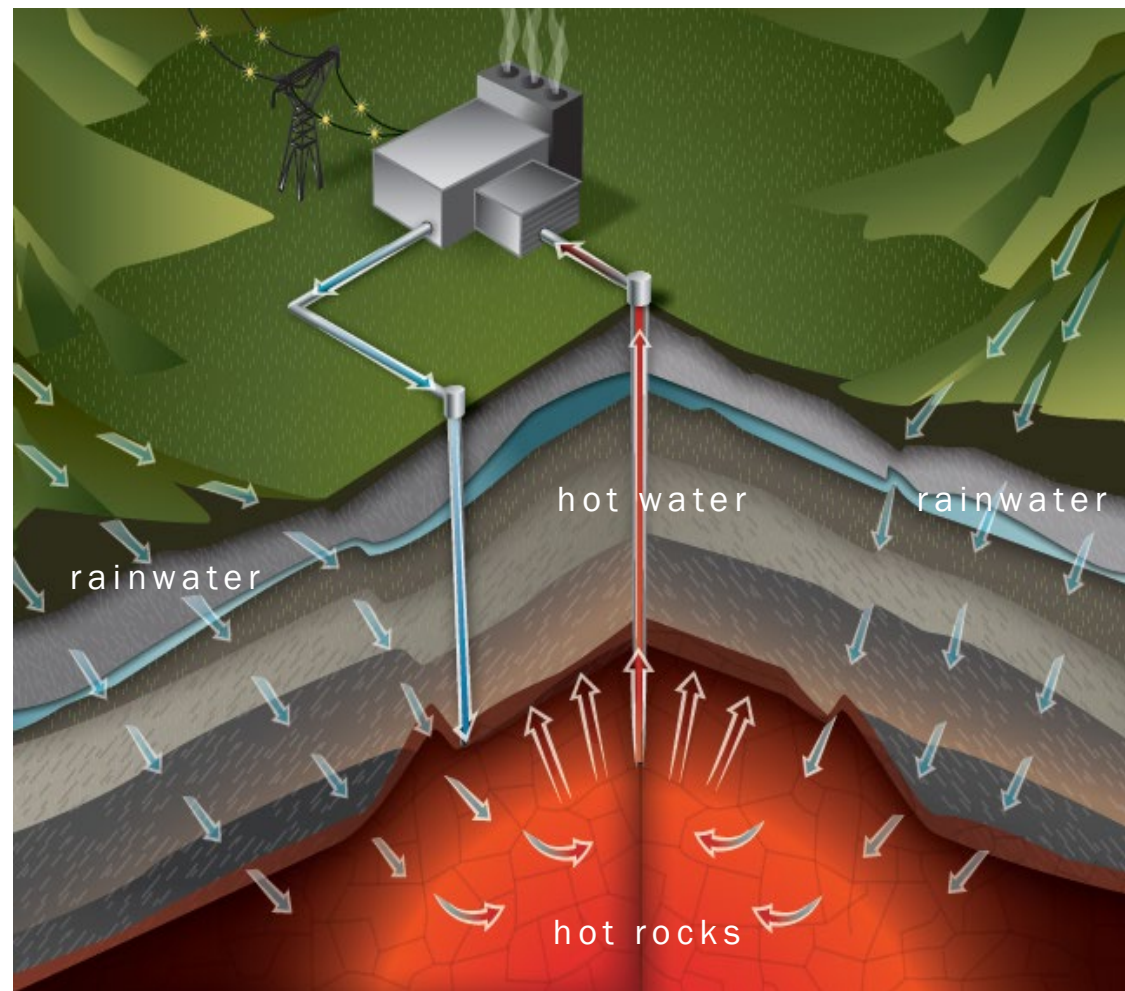
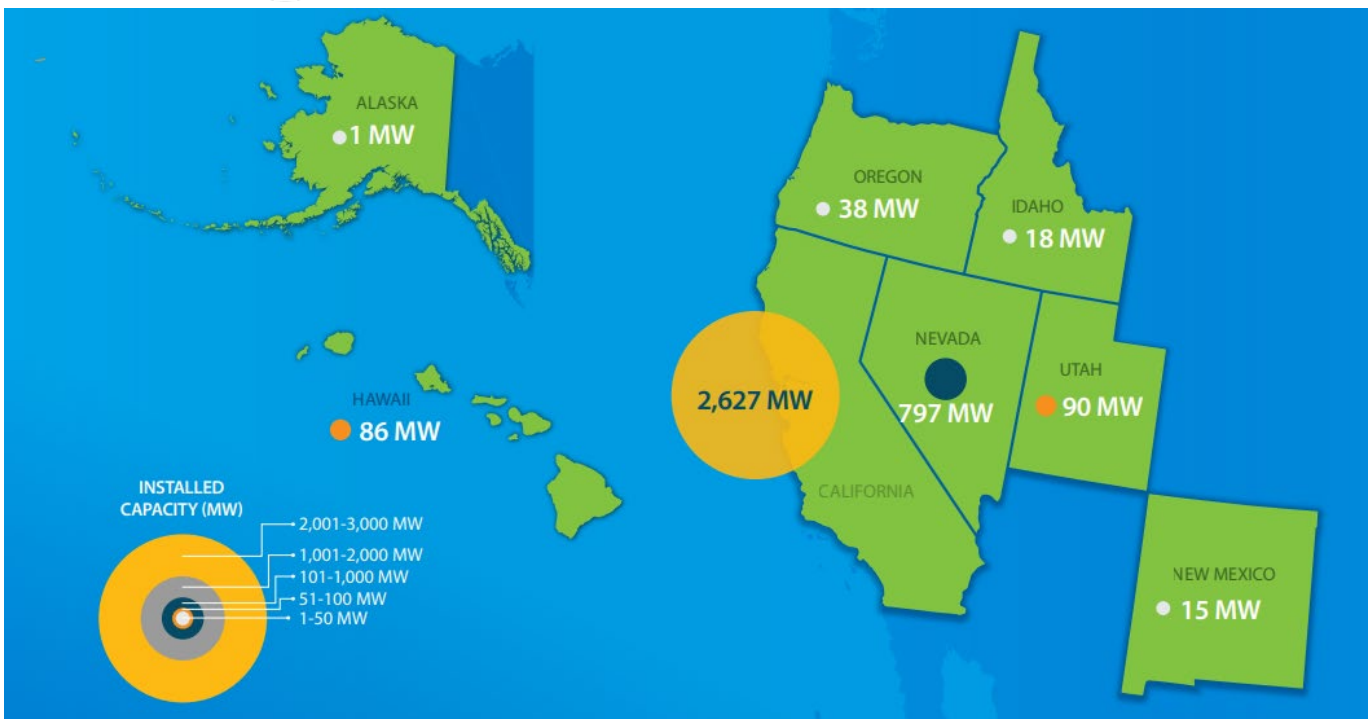
energy.gov/eere/geothermal/geothermal-basics



Conventional Geothermal Electricity Generation



A geothermal resource requires **fluid**, **heat**, and **permeability** to generate electricity. Conventional hydrothermal resources contain all three components naturally.

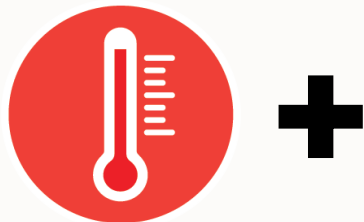


2021 Geothermal Market Report [nrel.gov/docs/fy21osti/78291.pdf](https://www.nrel.gov/docs/fy21osti/78291.pdf)



What are Enhanced Geothermal Systems?

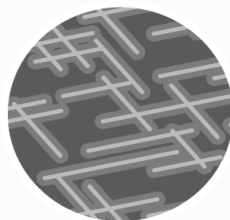
Stranded HEAT is
EVERYWHERE



Inject
fluid



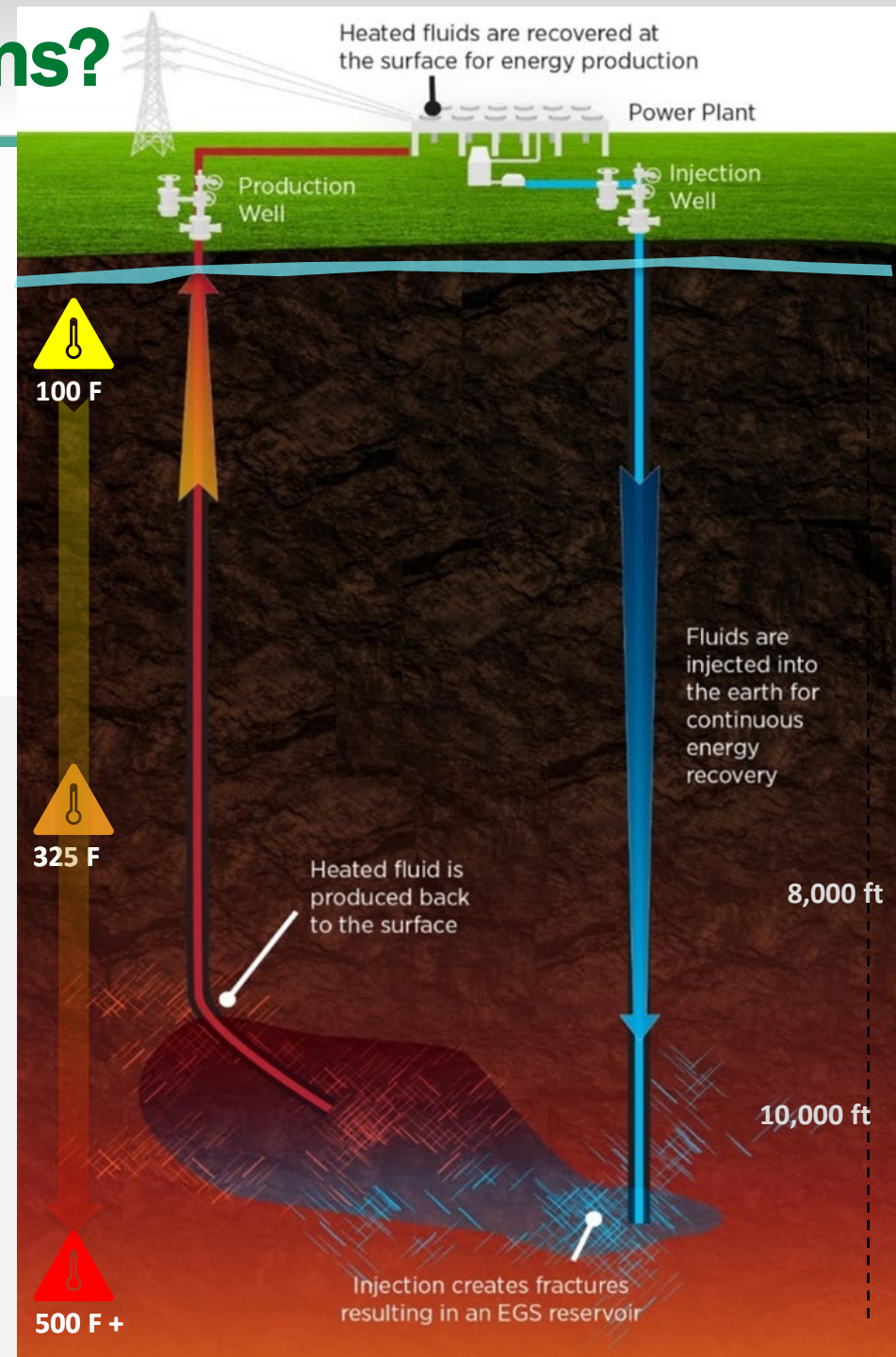
Create
pathways



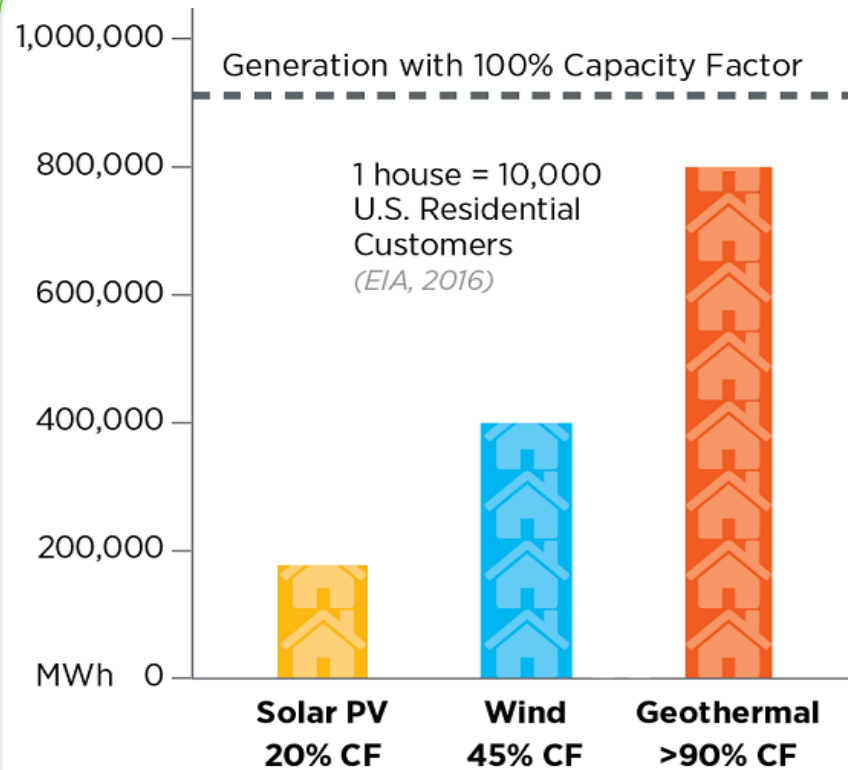
NATIONWIDE POTENTIAL for

- Dispatchable
- Baseload
- Carbon-free

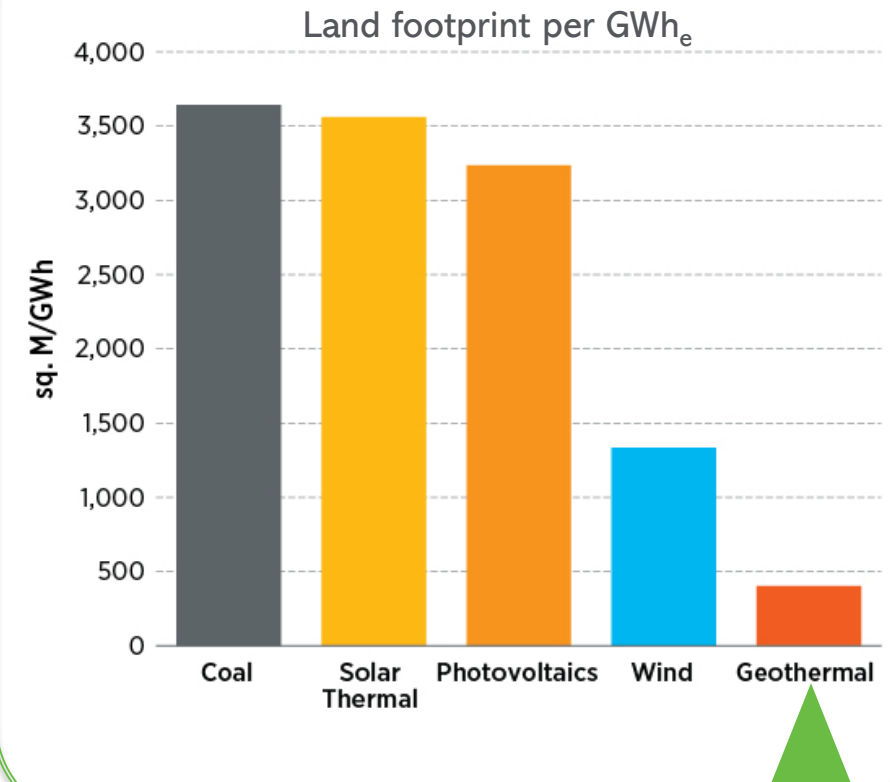
POWER + HEATING AND COOLING



Always ON



Compact

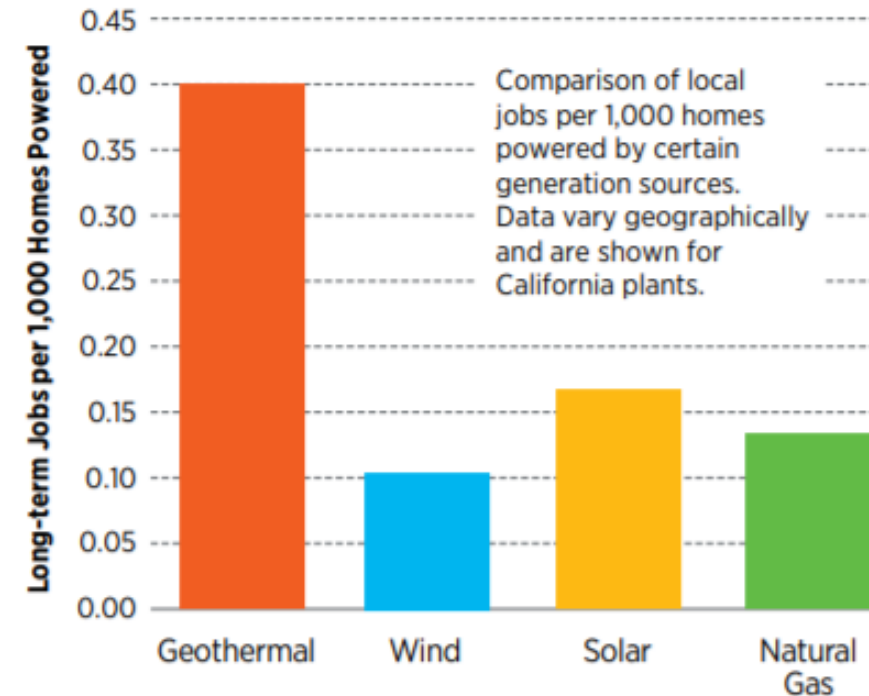




At a local level, geothermal power plants can provide 2x the long-term jobs per powered household vs other utility-scale power-generation technologies

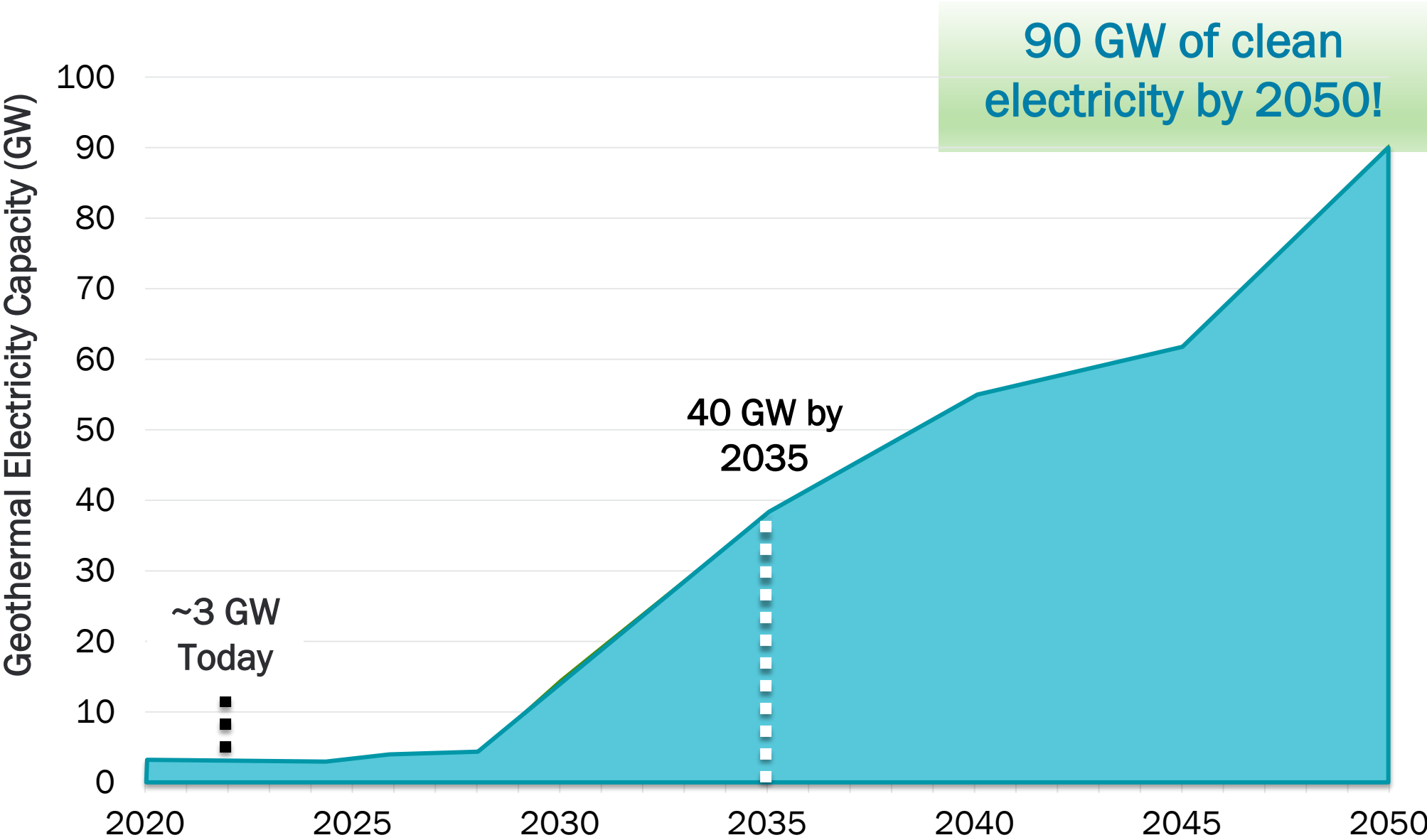


The geothermal industry could support up to **262,000** gross jobs by 2050.





Enhanced Geothermal Shot™

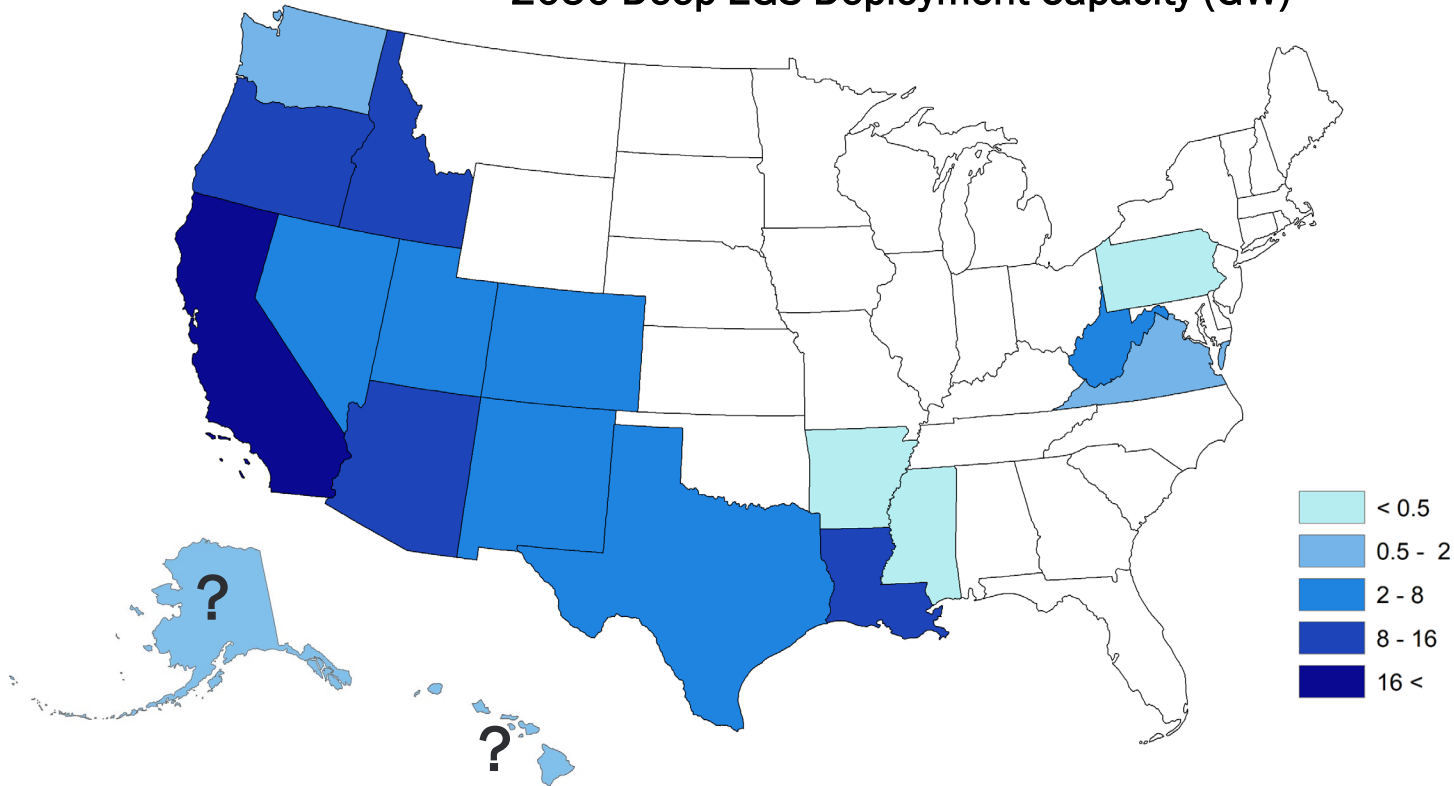




Enhanced Geothermal Shot™

Achieving the Enhanced Geothermal Shot™ target (\$45/MWh by 2035) will enable access to the five terawatts of heat resource in the United States, driving U.S. leadership in EGS and enabling a carbon free energy future.

2050 Deep EGS Deployment Capacity (GW)



90 GWe by 2050



Nationwide expansion of EGS for firm, flexible, secure power; grid stability



Clean, efficient heating and cooling for U.S. households nationwide



Just transition and leveraging of skilled fossil fuel workers; up to 262,000 gross jobs by 2050



Economic growth for negatively impacted communities



Opportunity for other important industries and domestic supply of critical materials



EGS Deployment and Technical Challenges

DEPLOYMENT

Public Awareness



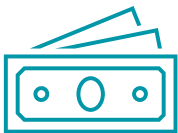
Permitting & Development Timelines



Valuation



Financing



TECHNICAL

DEEP

4,000 to
>10,000 feet
in the
subsurface!



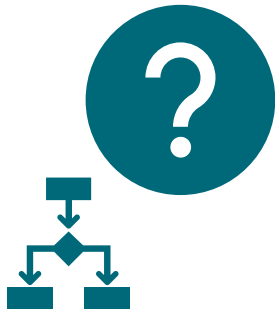
EXTREME

Hot, hard, abrasive
rock, corrosive
conditions



UNKNOWN

- Lack of data
necessary to
approximate the
subsurface



Frontier Observatory for Research in Geothermal Energy (FORGE)

- Located near Milford, Utah, and led by the University of Utah, FORGE is a dedicated site for developing, testing, and accelerating breakthroughs in EGS technologies and techniques.
- The FORGE initiative started in 2015 with five projects, leading up to the selection of the Utah FORGE site and team in 2018.
- FORGE is GTO's largest funding initiative, enabled by \$200M+ in federal investment and decades of public and private research.
- FORGE is a flagship research location for geothermal energy and one of the best-characterized geothermal sites in the world.





Bipartisan Infrastructure Law EGS Pilot Demos

SEC. 41007. Enhanced Geothermal Systems Demonstrations

Topic 1: EGS Proximal: Demos using existing infrastructure proximal to existing geothermal/hydrothermal development w/immediate potential for electrical power production.

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

Topic 3: Super-hot / Supercritical EGS: Super-hot/supercritical EGS demos at well-characterized sites w/near-term electric power production potential.

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

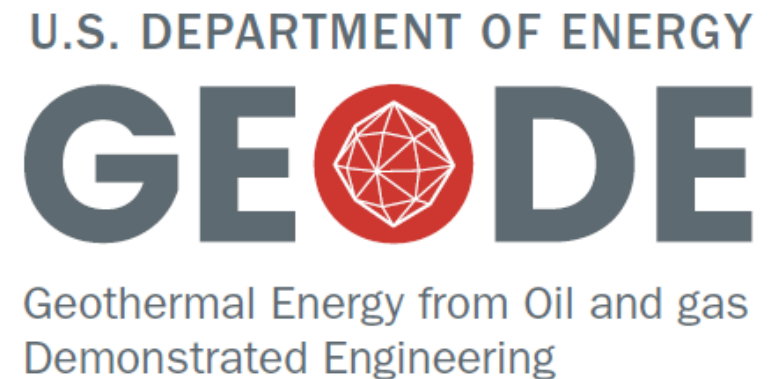
Applications are under review.



Leveraging Oil and Gas to Geothermal

- Geothermal Energy from Oil and gas Demonstrated Engineering ([GEODE](#)) initiative
 - 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.
 - Will issue future competitive solicitations for analysis, RD&D, and workforce efforts

GTO recently selected team comprising Project Innerspace, Geothermal Rising, and the Society of Petroleum Engineers as the GEODE consortium administrator.





Wells of Opportunity (WOO)

- Partners GTO with well owners or operators to help cost effectively increase geothermal power by field testing EGS technologies and techniques within existing wells
- WOO ReAmplify: \$8.4 million for four projects to help establish commercial viability of geothermal energy production from existing hydrocarbon fields
- **Four ReAmplify projects selected in 2022:**
 - Geothermix, LLC
 - University of Oklahoma
 - Transitional Energy
 - ICE Thermal Harvesting



- ✓ Utilizes the nation's abundant heat resource
- ✓ Provides firm, flexible, reliable, renewable power
- ✓ Can help decarbonize the grid and address the climate emergency
- ✓ Supports dramatic growth within the non-electric sector for heating and cooling
- ✓ Creates thousands of valuable energy sector jobs
- ✓ Creates economic opportunities for negatively impacted communities
- ✓ Improves grid stability
- ✓ Enables other important industries such as domestic supply of critical materials





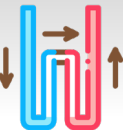
Geothermal in the Inflation Reduction Act

- 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**, for purchase of a heat pump (geothermal or air source).



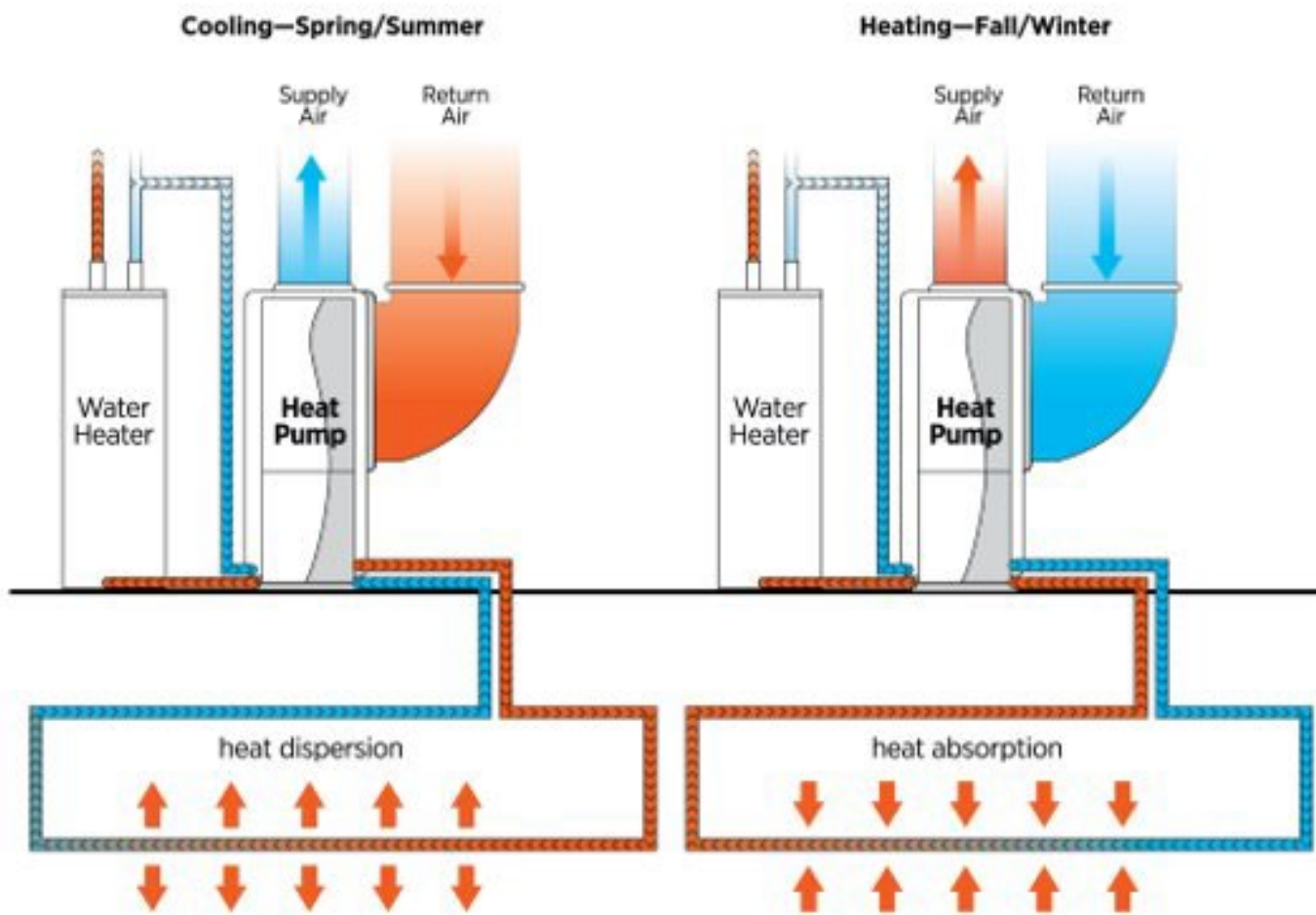
The Inflation Reduction Act of 2022, **H.R. 5376**





Low-Temperature and Coproduced Resources

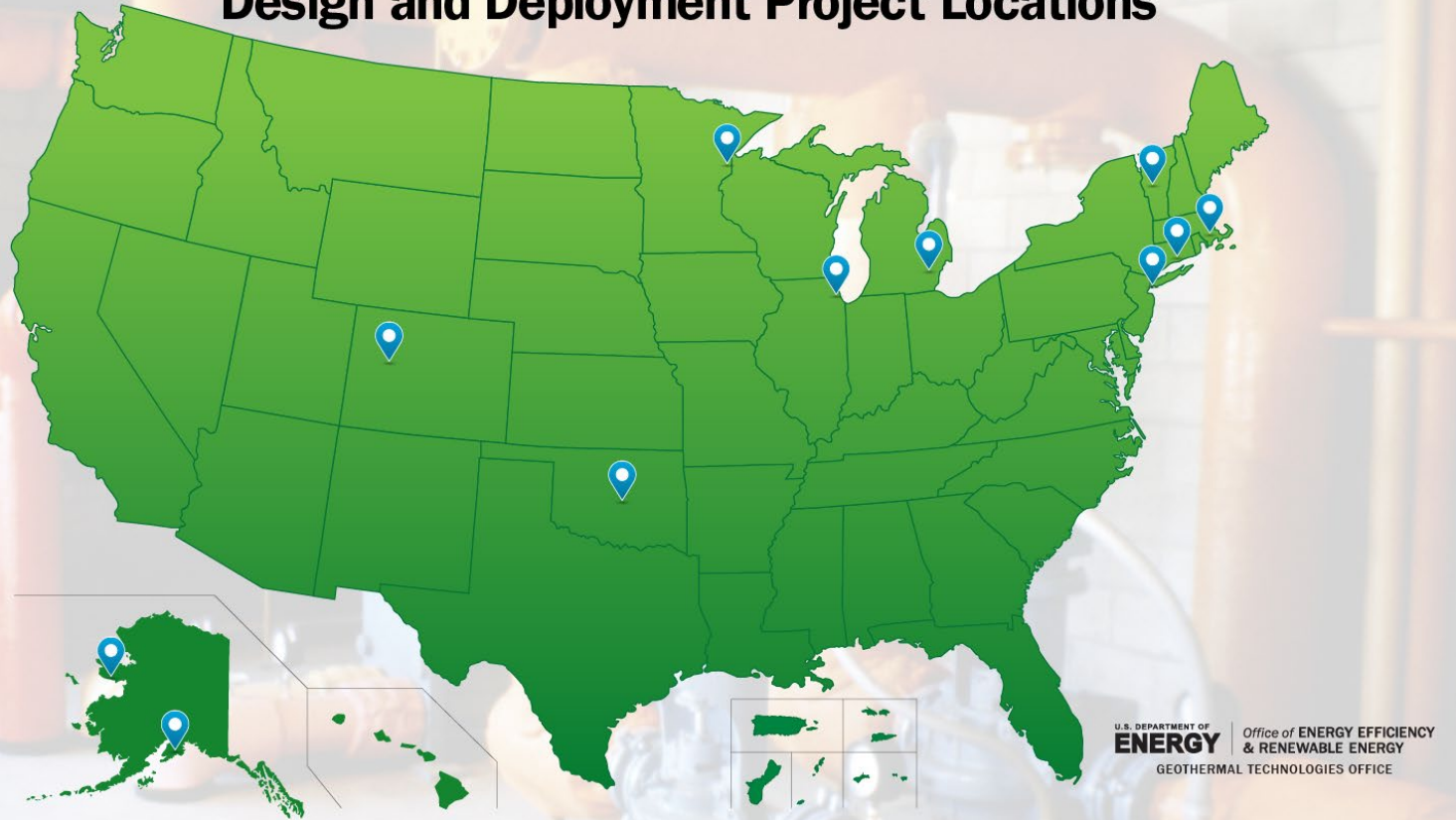
Geothermal resources $< 300^{\circ}\text{F}$ (150°C); resources, including hybrid energy designs, that can be co-developed with other clean energy technologies; direct use of thermal resources for process and space heating applications, geothermal heat pumps, district-scale geothermal heating and cooling systems, and deep direct use; and thermal energy storage.



Heat exchangers and circulation pumps for the geothermal district heating system in Klamath Falls, OR. Photo courtesy Geo-Heat Center (NREL Pix 03694)

Community-Focused Geothermal

Community Geothermal Heating and Cooling Design and Deployment Project Locations



Selected 11 communities in 10 states to assess and design community-scale geothermal heating and cooling systems

Urban

- Ann Arbor, MI
- **Chicago, IL**
- Duluth, MN
- Framingham, MA
- New York City, NY
- Wallingford, CT

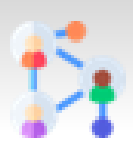
Rural

- **Carbondale, CO**
- Middlebury, VT
- Seward, AK
- Shawnee, OK

Remote

- Nome, AK

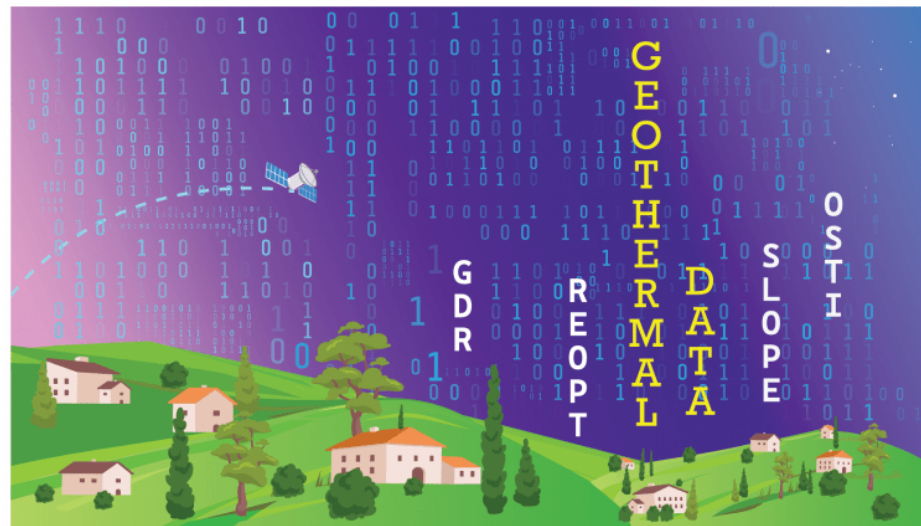
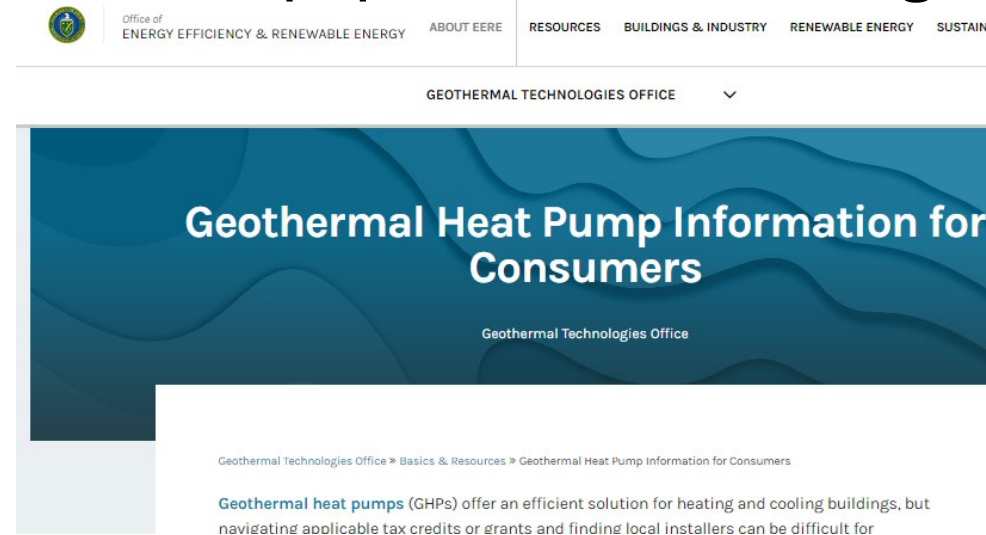
energy.gov/eere/geothermal/community-geothermal-heating-and-cooling-design-and-deployment



Resources and Outreach

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

- Storymaps
- Updated Website
- Stakeholder Toolkits
- The Drill Down
- Infographics
- Project Postcards
- Funding Opportunity Quick Guides
- Fact Sheets
- Presentations



geothermal.energy.gov



Thank You!



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

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