

# Investing in Opportunity: How the Geothermal Technologies Office is Supporting Geothermal Everywhere

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# What are Geothermal Resources?

- Geothermal literally means “earth heat,” or the heat beneath our feet.
- When considering a geothermal resource definition and/or right, the term “heat” could be used to ensure inclusivity of all technologies seeking to harness the geothermal resource in question.
- This could include the use of specific terminology for what is encompassed within a geothermal right (i.e., what can and cannot be extracted from the subsurface).
- The definition of a geothermal resource in the U.S. Code of Federal Regulations is:
  - “Geothermal steam and associated geothermal resources means:
    - All products of geothermal processes, including indigenous steam, hot water, and hot brines;
    - Steam and other gases, hot water, and hot brines resulting from water, gas, or other fluids artificially introduced into geothermal formations;
    - Heat or other associated energy found in geothermal formations; and
    - Any byproducts” (43 CFR § 3200.1)



# 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



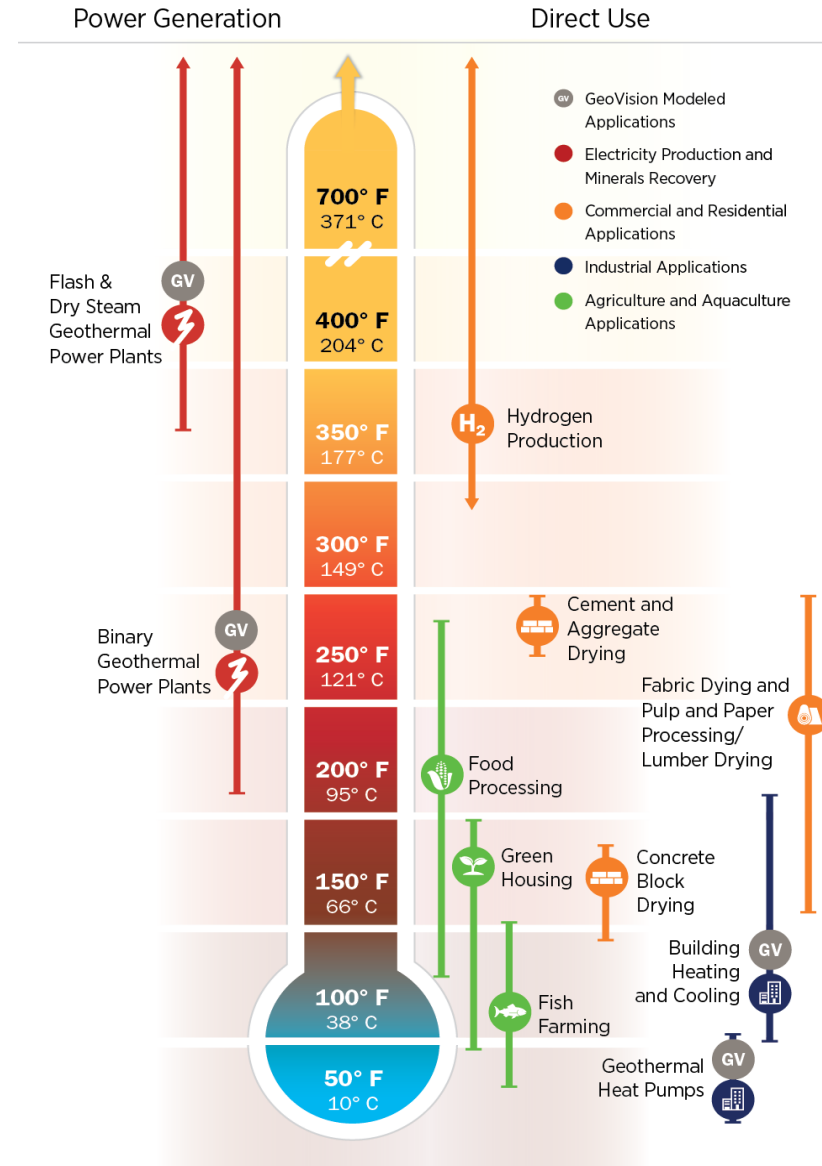
## Direct Use

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



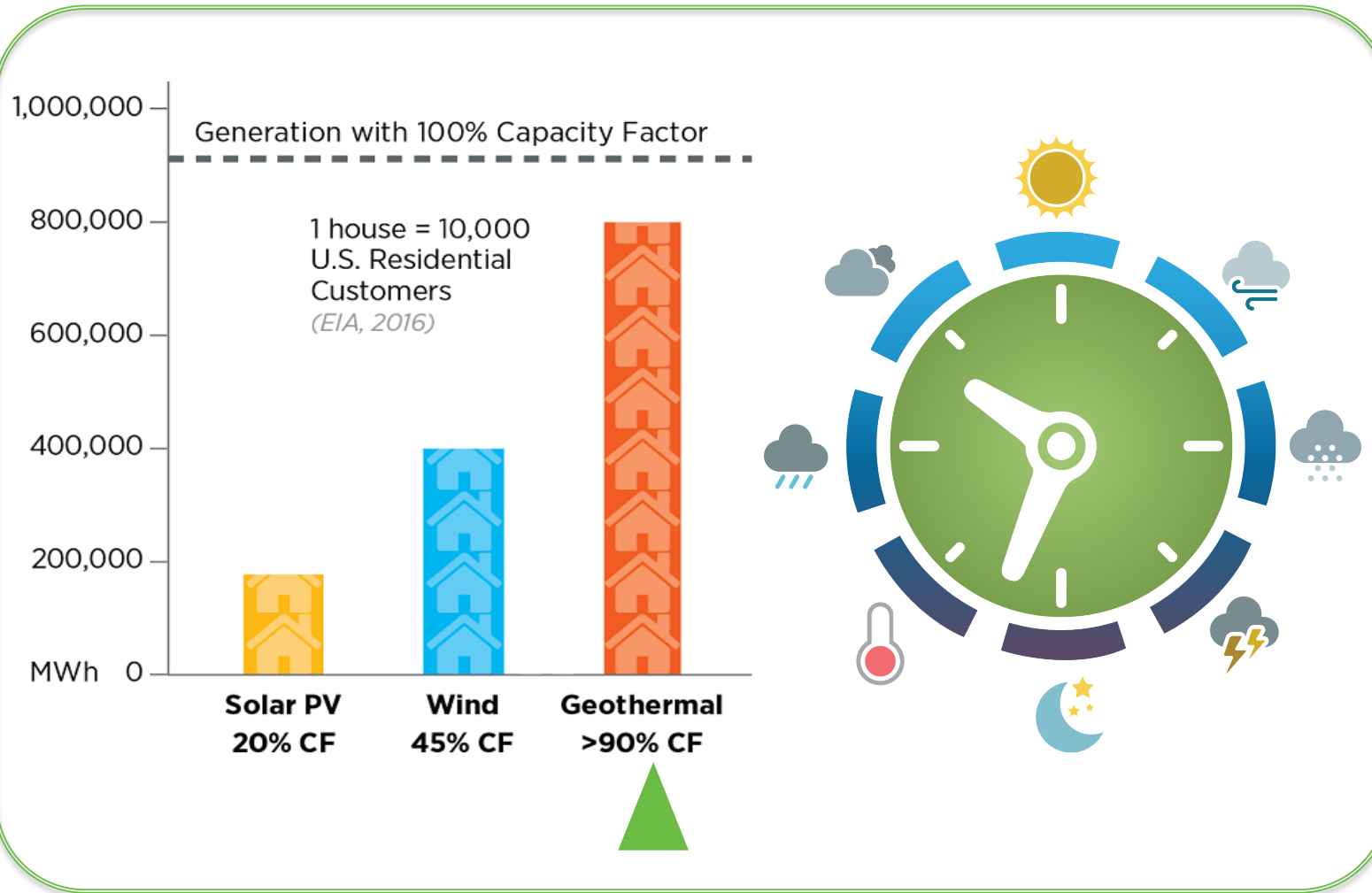
## Heating & Cooling

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

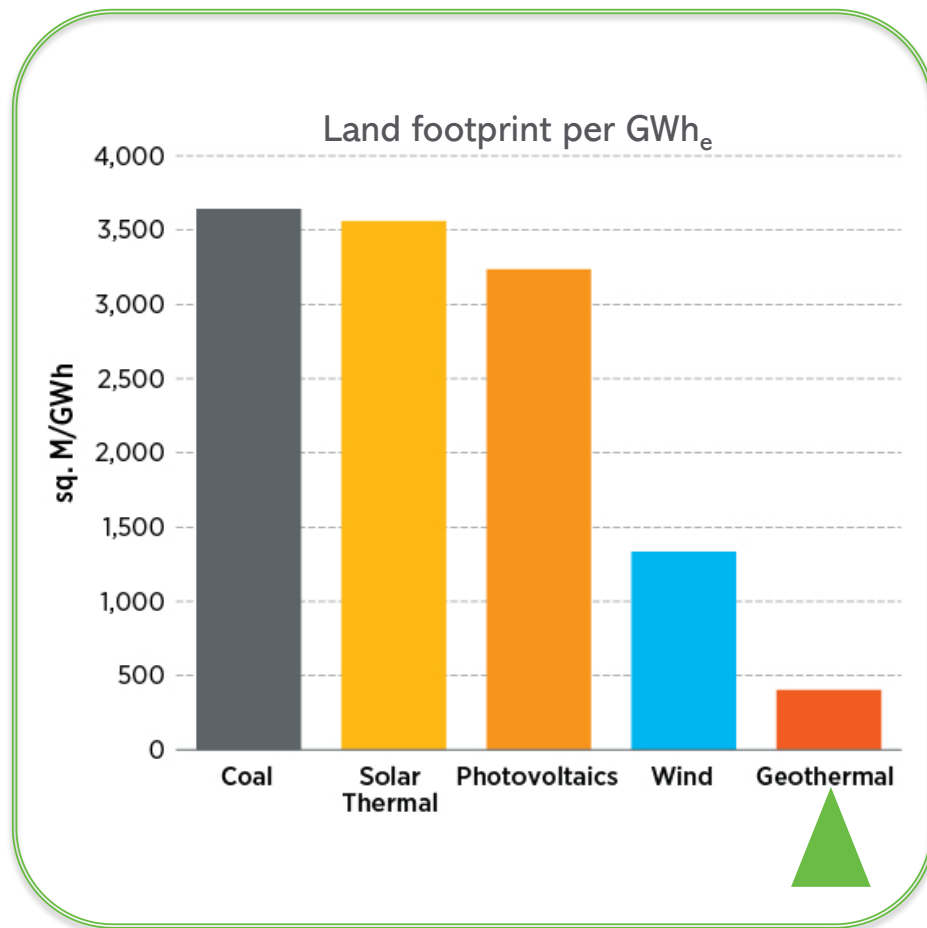


# Benefits of Geothermal Energy

## Firm and Flexible



## Compact





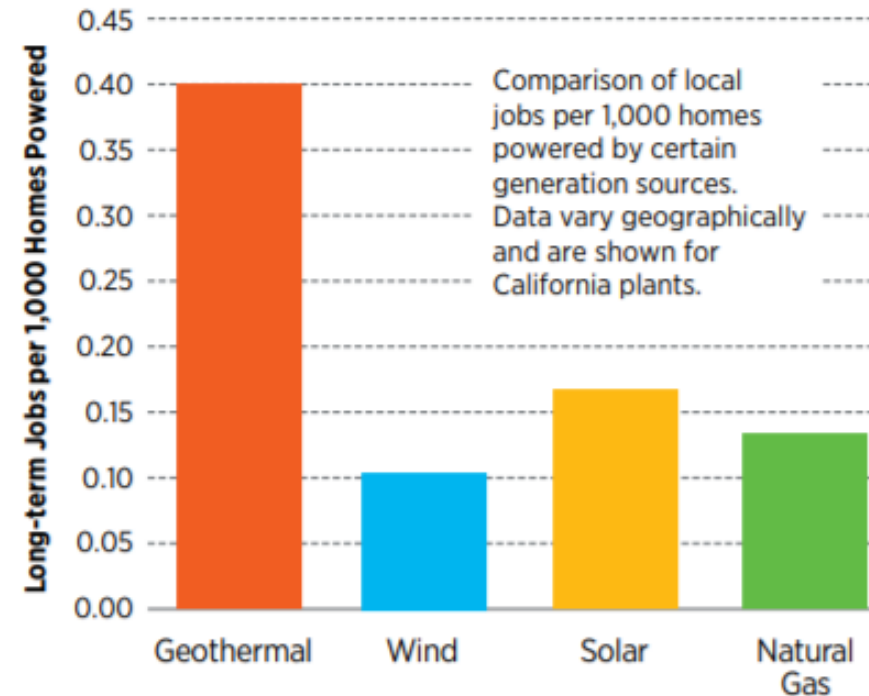
# Benefits of Geothermal Energy



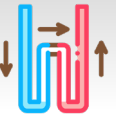
At a local level, geothermal power plants can provide 2x the long-term jobs per powered household vs other utility-scale power-generation technologies



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



Source: GeoVision Analysis (DOE, 2019) [energy.gov/eere/geothermal/geovision](https://energy.gov/eere/geothermal/geovision)



# 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



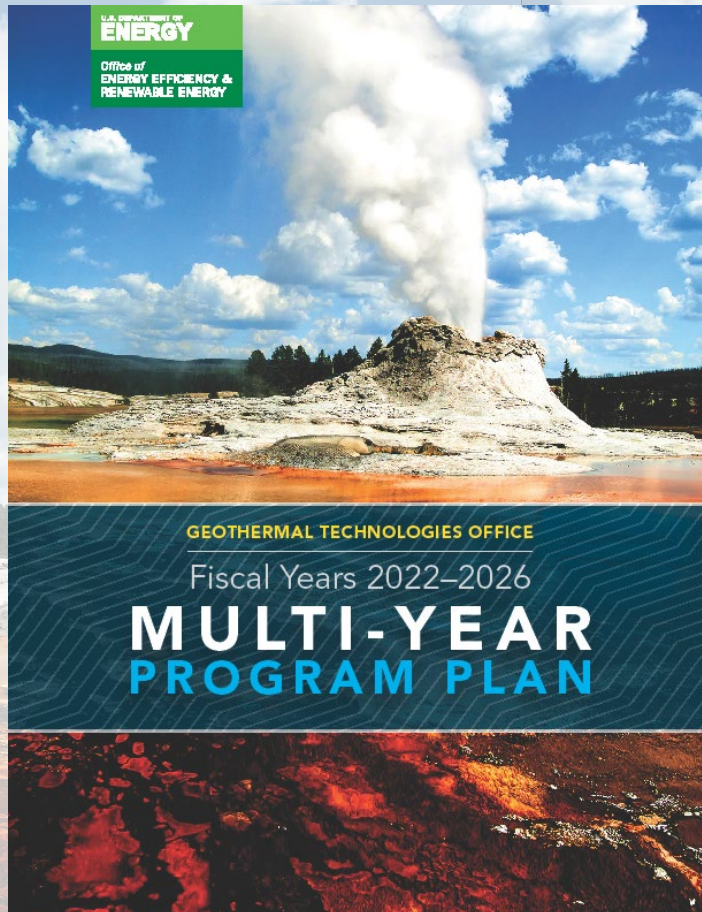
Reduce up to 410 GW of nationwide generation capacity requirements – bolstering seasonal US grid resilience



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

# GTO's Multi-Year Program Plan (MYPP)

The **MYPP** 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>

## 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

Use geothermal heating and cooling to decarbonize buildings and the electricity grid, eliminating up to 7 GT of carbon nationwide by 2050.

## STRATEGIC GOAL 3

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

# GTO Mission and Program Areas

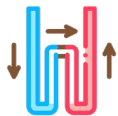
GTO's mission is to increase geothermal energy deployment through research, development, and demonstration of innovative technologies that enhance exploration and production.



## Data, Modeling, and Analysis



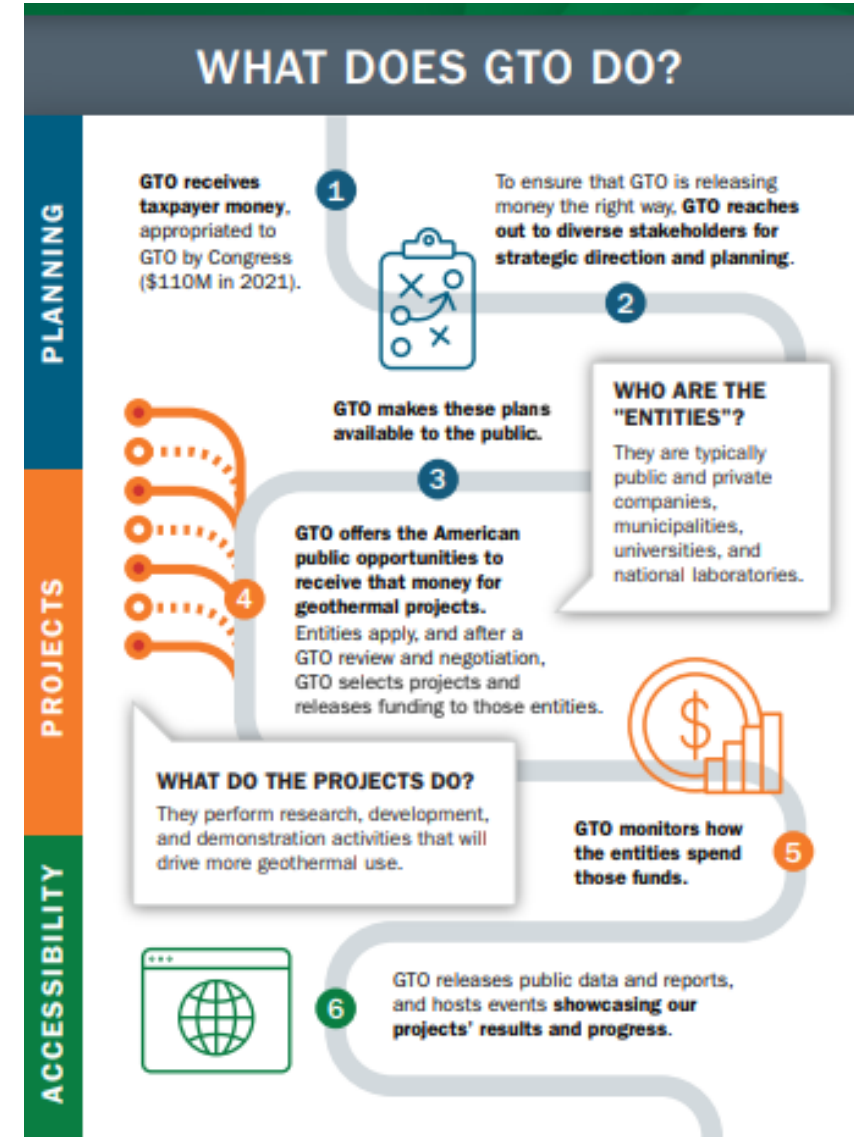
## Hydrothermal Resources



## Low-Temperature and Coproduced Resources



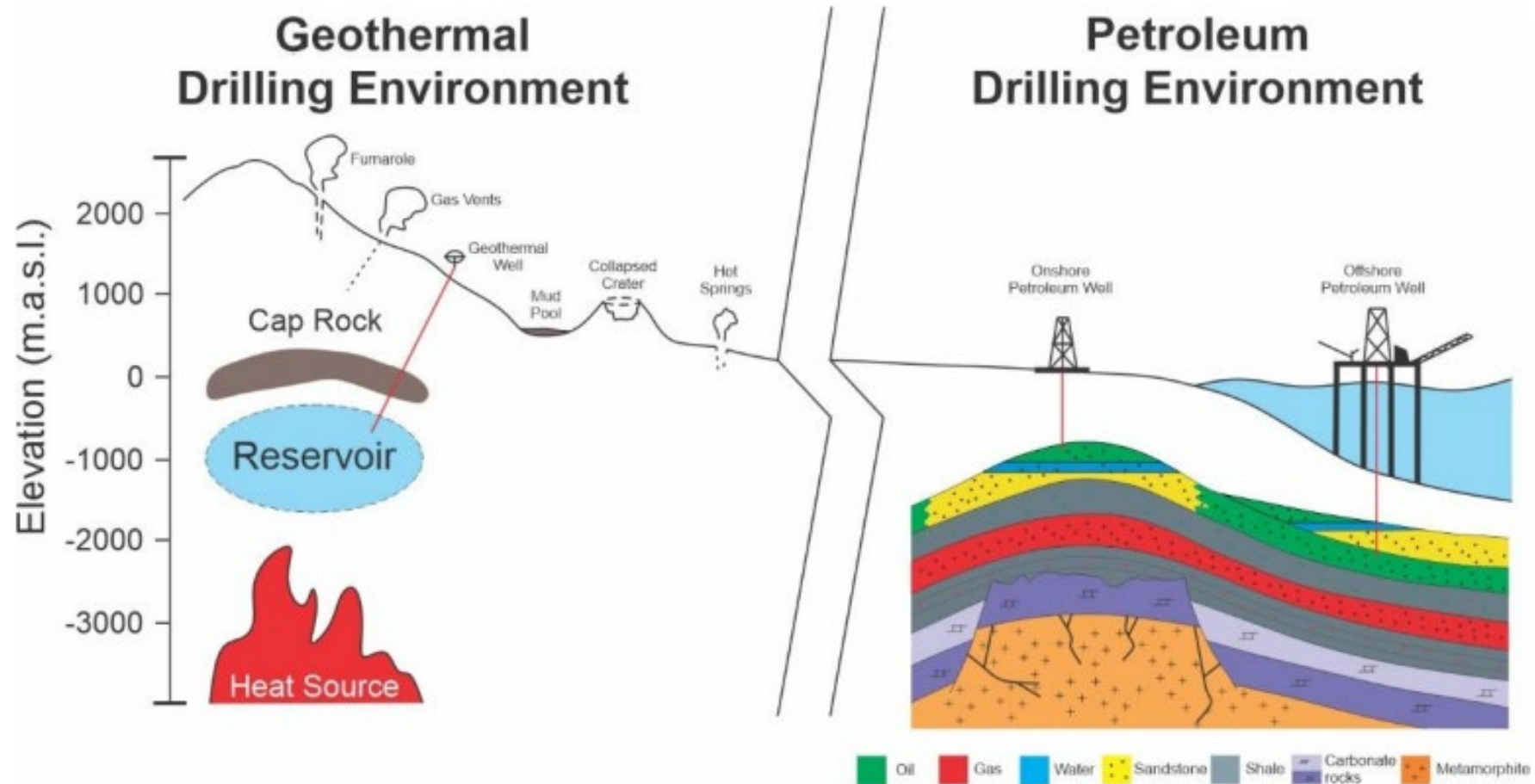
## Enhanced Geothermal Systems



[energy.gov/eere/geothermal/geothermal-basics](https://energy.gov/eere/geothermal/geothermal-basics)

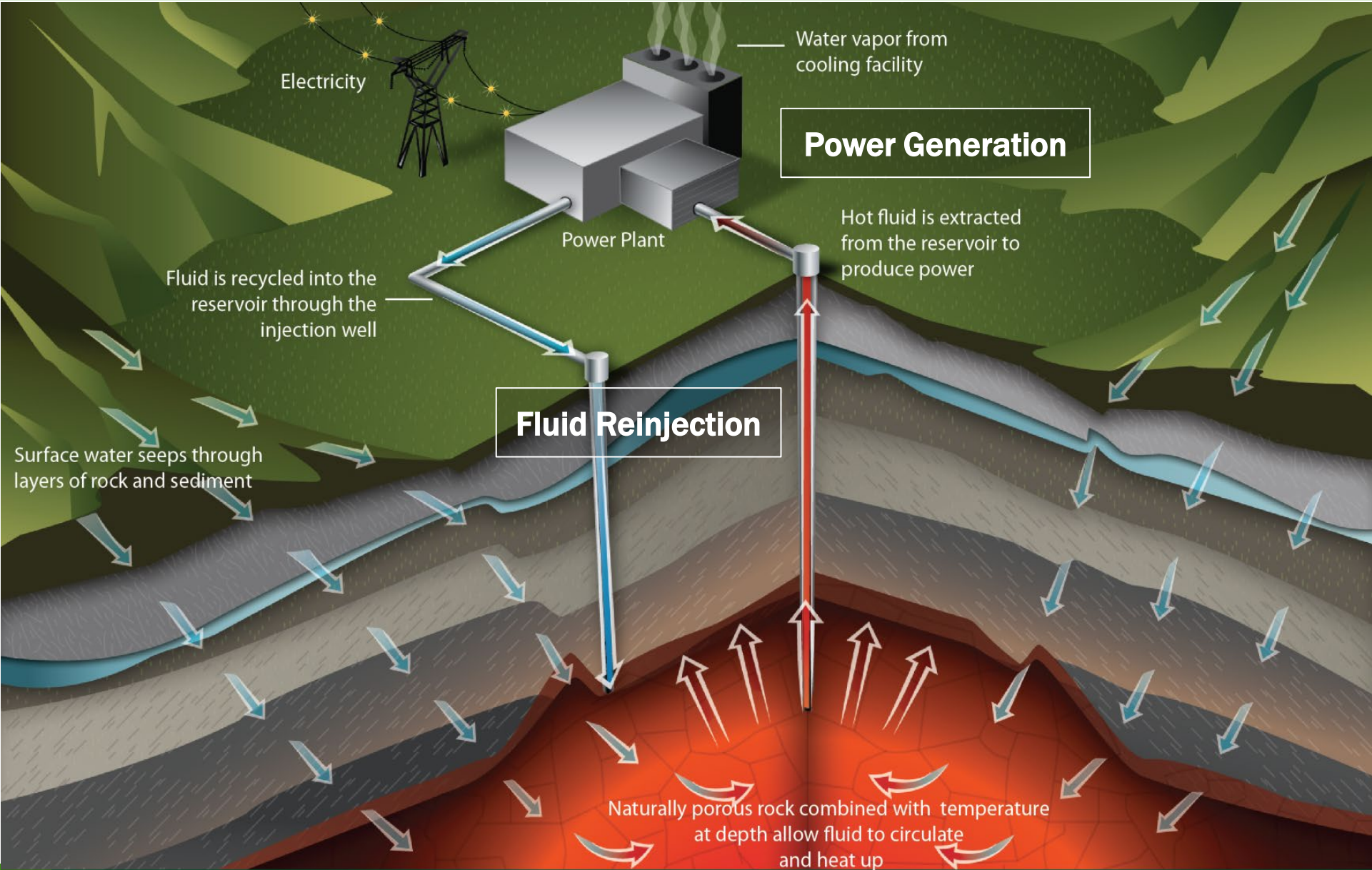


# Geothermal Power vs. Oil and Gas Subsurface Environment



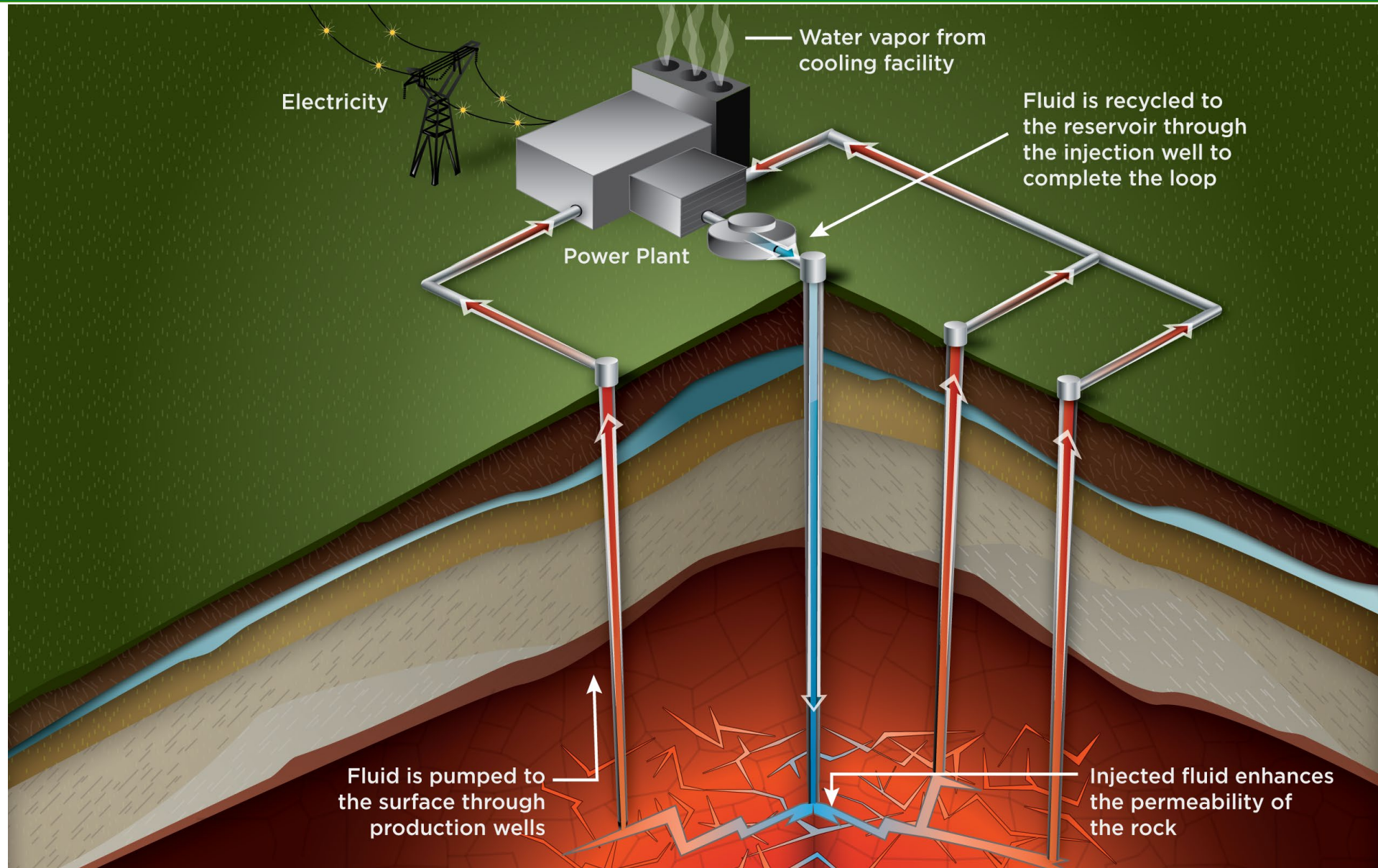
<https://pangea.stanford.edu/ERE/db/GeoConf/papers/SGW/2022/Purba.pdf>

# Hydrothermal Generation





# Enhanced Geothermal Systems (EGS) Generation





# Geothermal Power vs. Oil and Gas Wells

Attribute	Geothermal	O&G
Temperature	300°F – 650°F and higher	<350°F
Lithology	Hard, abrasive volcanics, intrusive, metamorphics	Less hard, sedimentary
Depth	5,000–16,000 ft	Up to 10,000 ft (onshore conventional)
Drilling Pressure	Higher	Lower
Bottomhole Diameter	8"-12"	5-7" production interval
Fluid Flow	50,000 bpd average, potentially corrosive	<5,000 bpd, less corrosive



# Geothermal Power vs. Oil and Gas Wells

## Oil and Gas

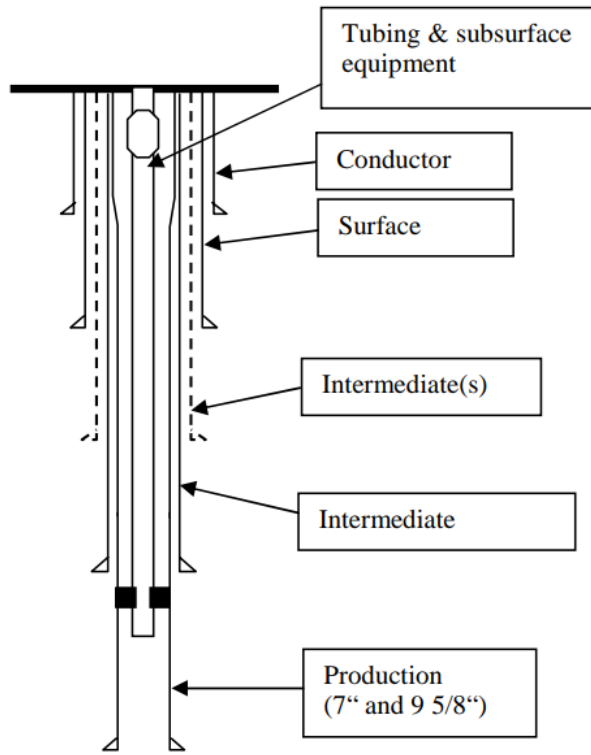
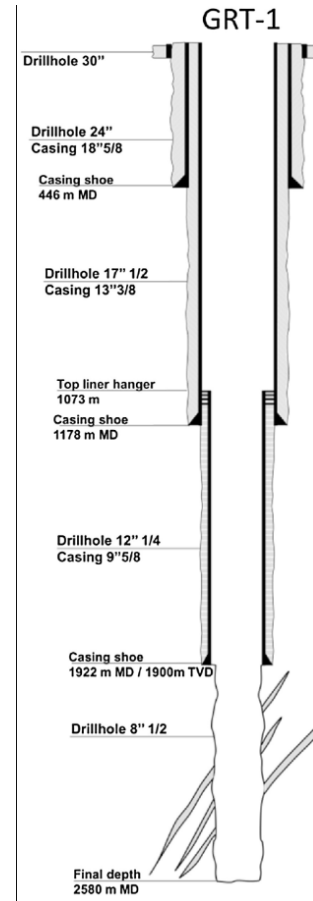


Fig. 6. Completion schematic for a typical gas well.

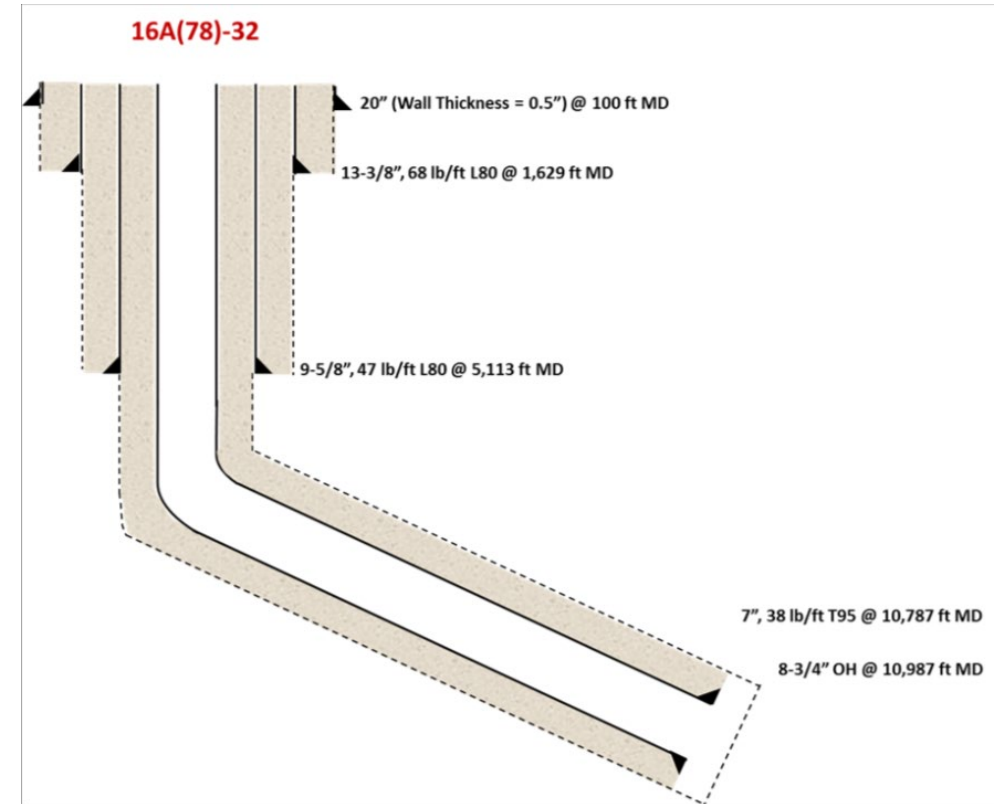
Teodoriu and Falcone, 2008

## Hydrothermal



Baujard et al., 2017

## FORGE EGS Well



Pers. Comm. with FORGE team

# Improving Geothermal Project Permitting Timelines



- GTO led and participated in an interagency task force comprising federal agencies subject to a 2021 Memorandum of Understanding to Establish a Program to Improve Public Land Renewable Energy Project Permit Coordination, plus state agencies from California and Nevada.
- Task Force effort included:
  - A series of stakeholder engagement events and Tribal Government listening sessions
  - Virtual forums with industry developers and environmental non-governmental organizations
  - Listening sessions with Nevada and California Tribal Government representatives
  - Final Task Force synthesis meeting
  - Resulting Task Force report.

[nrel.gov/docs/fy23osti/84684.pdf](https://nrel.gov/docs/fy23osti/84684.pdf)



# Improving Geothermal Project Permitting Timelines



- GTO is now co-chairing along with Bureau of Land Management a **RECO Interagency Geothermal Permitting Working Group** including federal and state agency representatives to collaboratively address opportunities for action identified through the Task Force.
- Areas of Focus:
  - Development of a Database for Geothermal Project Permitting with Interagency- and Public-Facing Dashboards
  - Updates to U.S. Geothermal Resource Assessments
  - Permitting process information that centralizes the interagency permitting research body of knowledge
  - Expanded and Standardized Pre-application Meetings
  - Utilizing Bureau of Indian Affairs' Indian Service Center


# Uniform State Regulations Report

- GTO funded the National Renewable Energy Laboratory to develop a report **summarizing existing state and federal geothermal regulations and key considerations for state-level decisionmakers.**
- Process included:
  - Reviewing and cataloguing existing state (i.e., 50 state survey) and federal geothermal regulations
  - Compiling documentation of regulatory best practices from geothermal and other extractive industries (i.e., oil & gas, mining)
  - Establishing a volunteer Geothermal Regulatory Stakeholder Working Group (SWG) comprising geothermal and oil & gas industry representation, state regulators, and academia to advise and review the report.
    - The SWG met ~1x/month over the course of a year to discuss specific topics and review existing state geothermal regulations.



# Uniform State Regulations Report

- Covers **five main topical areas** broken out into individual sections:
  - Geothermal resource ownership and definition
  - Leasing process
  - Exploration approval process
  - Drilling/wellfield development approval process
  - UIC processes



**Topics and Considerations for Developing State Geothermal Regulations**

Aaron Levine, Faith Martinez Smith, and Heather Buchanan

*National Renewable Energy Laboratory*

NREL is a national laboratory of the U.S. Department of Energy  
Office of Energy Efficiency & Renewable Energy  
Operated by the Alliance for Sustainable Energy, LLC

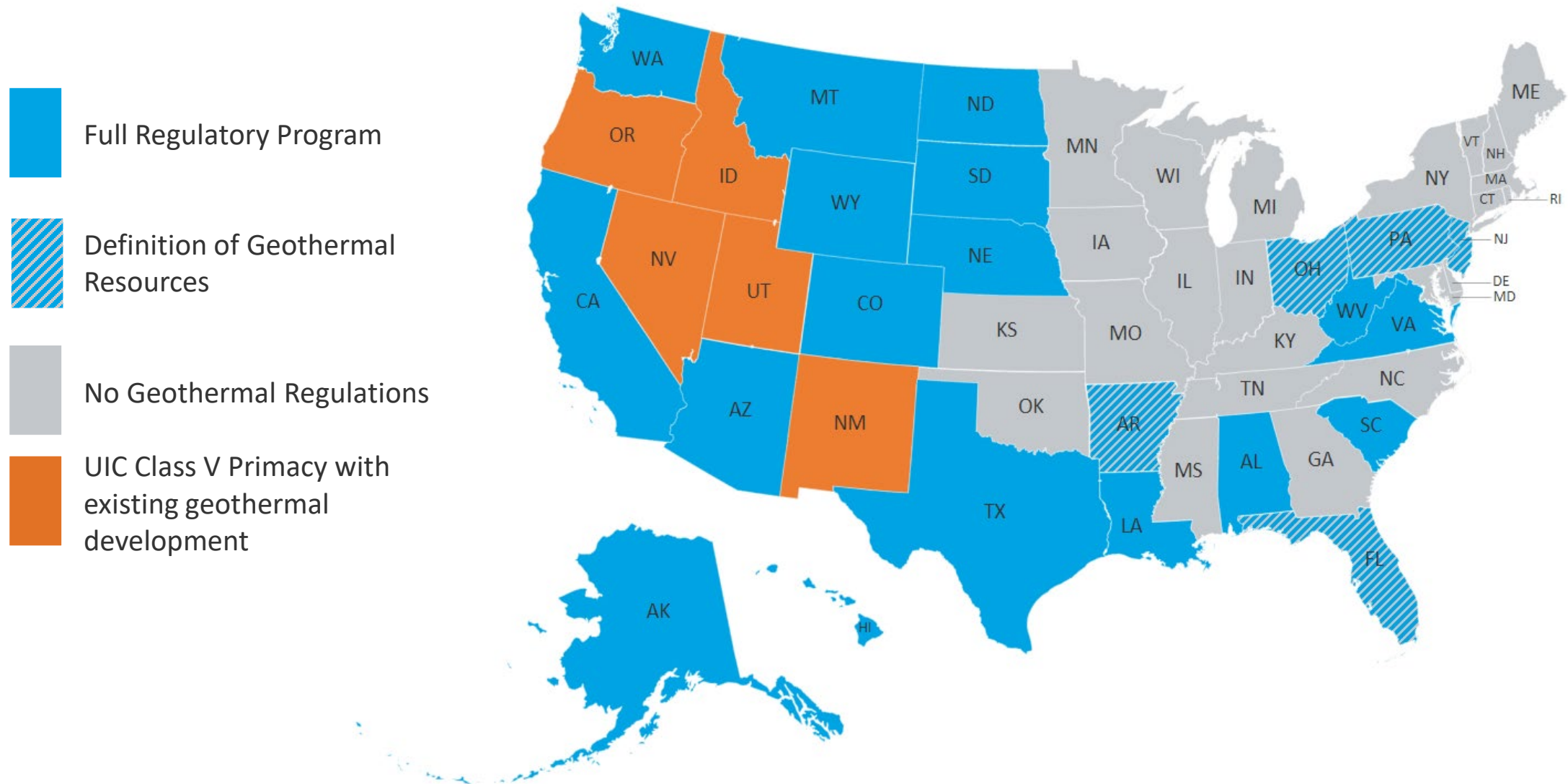
Technical Report  
NREL/TP-6A20-86985  
September 2023

This report is available at no cost from the National Renewable Energy Laboratory (NREL) at [www.nrel.gov/publications](http://www.nrel.gov/publications).

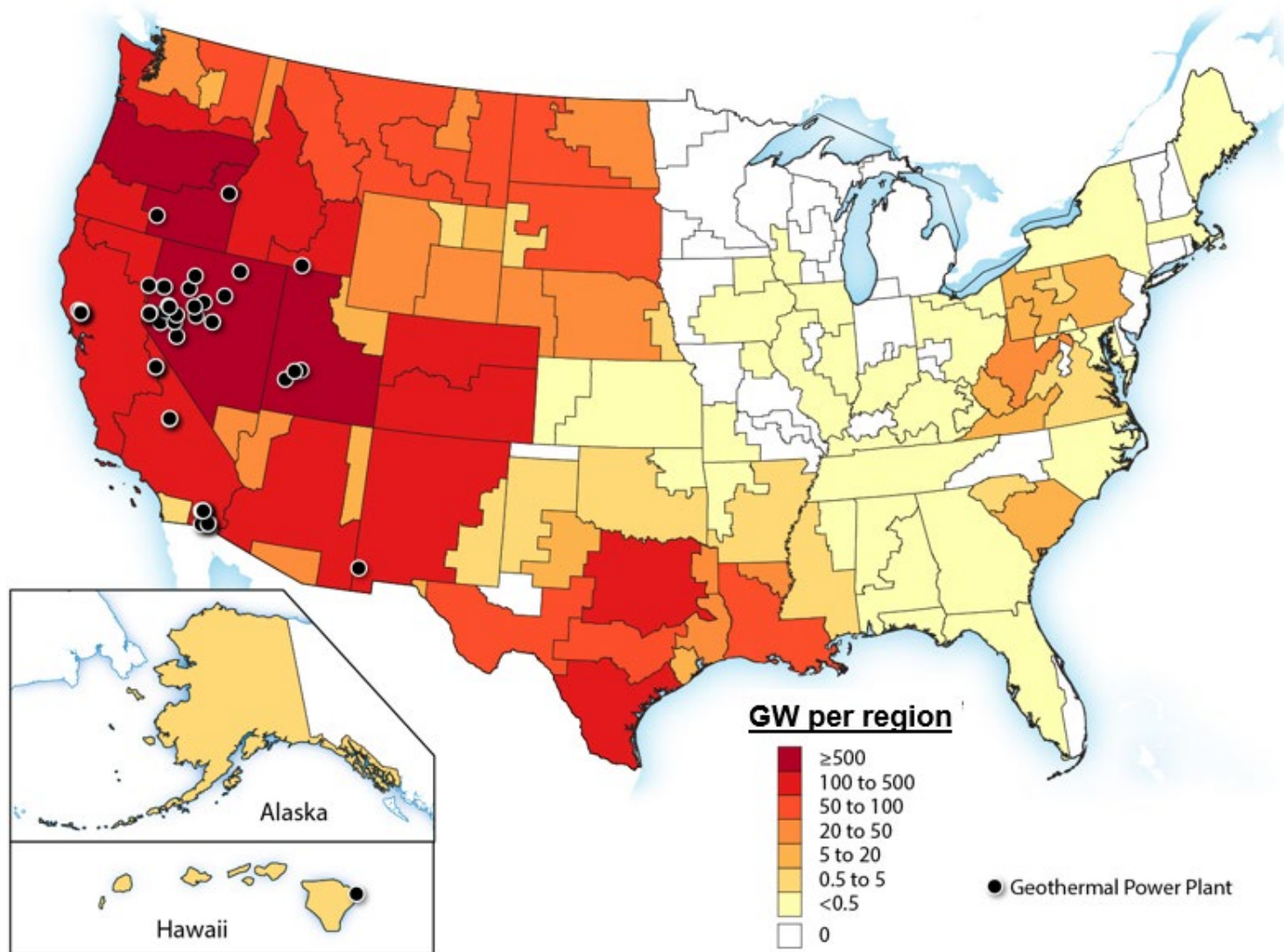
Contract No. DE-AC36-08GO28308

<https://www.nrel.gov/docs/fy23osti/86985.pdf>

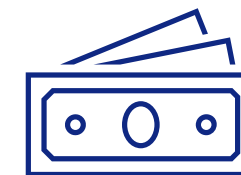
# State-Level Geothermal Regulations: UIC and Beyond



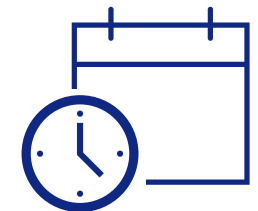
# Enhanced Geothermal Shot™ Geothermal Capacity



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



\$ 45/MWh



2035

# Thank You!



Get the hottest geothermal news from *The Drill Down*, the 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)

# Questions?

The **Geothermal Technologies Office (GTO)** works to reduce the cost and risk associated with geothermal development by supporting innovative technologies that address key exploration and operational challenges.

Visit us at: [www.energy.gov/eere/geothermal](http://www.energy.gov/eere/geothermal)

See what Energy Secretary thinks about geothermal in her geyser-side chat with GTO Director Susan Hamm: <https://bit.ly/GeyserSide>

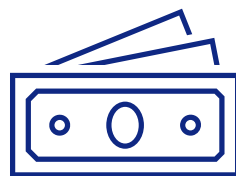
# Back Up

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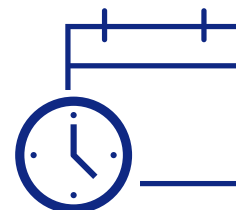
# Enhanced Geothermal Shot



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



\$ 45/MWh



2035

*GTO is built on a legacy of innovation.*

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.

[www.energy.gov/eere/geothermal/enhanced-geothermal-shot](http://www.energy.gov/eere/geothermal/enhanced-geothermal-shot)

# Enhanced Geothermal Shot

The Enhanced Geothermal Shot 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.

## Why EGS?

Nationwide potential for  
**CLEAN, FIRM, AND  
DISPATCHABLE ELECTRICITY**



Widespread deployment of  
**CARBON-FREE HEATING  
AND COOLING**

[www.energy.gov/eere/geothermal/enhanced-geothermal-shot](https://www.energy.gov/eere/geothermal/enhanced-geothermal-shot)



# Key Considerations: UIC Process

Underground injection control (UIC) processes are driven by the Federal Safe Drinking Water Act and the Environmental Protection Agency (EPA).

States may seek to obtain primacy from the EPA for all or specific classes of UIC wells. Geothermal injection wells are classified as Class V UIC wells.

Key considerations include:

- States without existing UIC Class V wells primacy may need to determine whether they should seek primacy for Class V wells.

States with Class V Primacy	Primary Enforcement Agency
Idaho	Idaho Department of Water Resources
Nevada	Nevada Division of Environmental Protection
New Mexico	New Mexico Environment Department
Oregon	Oregon Department of Environmental Quality
Utah	Utah Department of Environmental Quality