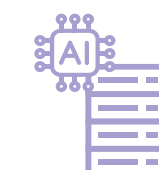
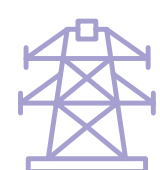




**INDUSTRY
OVERVIEW
SEGMENTS**

GEO THERMAL



INDUSTRY OVERVIEW SEGMENT – GEOTHERMAL

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Industry Overview

MARKET SIZE & GROWTH FORECASTS

Installed Capacity - As of 2024, the U.S. has approximately 3.7 gigawatts (GW) of installed geothermal capacity, with enhanced geothermal systems (EGS) representing the next generation of geothermal development. Globally, there is approximately 16 GW of installed geothermal energy capacity.

Market Value - The domestic geothermal market is estimated to be valued between \$3-4 billion, encompassing drilling, system development, power generation equipment, and related services. Globally, this market is valued between \$7-10 billion depending on methodology.

Future Expansion - Depending on modeling assumptions, reports estimate the geothermal market is expected to grow at a compound annual growth rate (CAGR) of around 5-7% through 2030. By 2030, the EGS market could reach \$4-11 billion globally. The United States has the potential to reach 60 GW of installed geothermal capacity by 2050, and IEA estimates global capacity could reach 800 GW by mid-century.

Investment Trends - Major federal investments have included \$60 million in DOE pilot projects announced in 2024, along with private investment from companies like Google and Microsoft seeking 24/7 clean energy for data centers and significant funding rounds for leading start-ups like Fervo and Sage Geosystems.

Leading States - Nevada, California, Hawaii, and Idaho lead in geothermal development, while new EGS projects are expanding in Texas, Utah, and Colorado.

Emerging Markets - EGS technology enables geothermal development in previously unsuitable locations, potentially expanding geothermal energy to most U.S. states. International markets include Australia, the Philippines, Japan, India and parts of Eastern Europe.

Technology Integration - EGS systems increasingly integrate with oil and gas drilling expertise, fiber optic monitoring, and advanced materials to create enhanced subsurface heat exchangers.



Industry Overview

MARKET DRIVERS

Baseload Clean Energy - EGS provides 24/7 carbon-free power generation, making it ideal for data centers, industrial facilities, and power grids.

Government Support - Federal tax incentives, DOE funding programs, and state renewable energy standards drive EGS development investments.

Technology Transfer - Advanced drilling techniques, human capital and skilled workforce from the oil and gas industry reduce costs and increase feasibility of EGS projects.

Corporate Demand - Technology and manufacturing companies seeking reliable clean energy for AI and data centers are driving long-term power purchase agreements.

CHALLENGES & CONCERNS

High Upfront Costs - EGS projects require significant capital investment for deep drilling and system development before revenue generation.

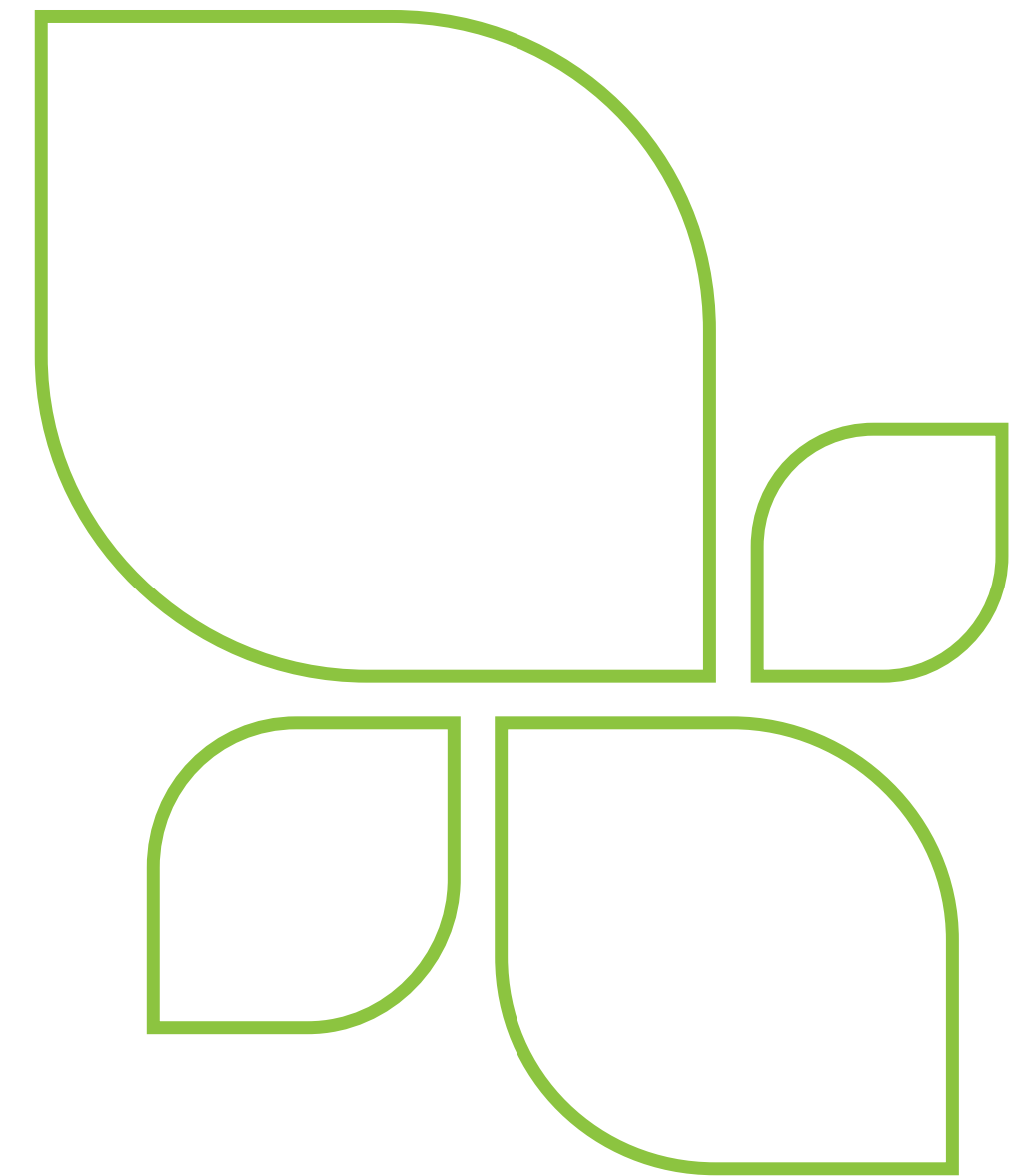
Technical Risks - Induced seismicity, drilling challenges, and reservoir performance uncertainties affect project economics.

Regulatory Framework - Limited regulatory experience with EGS technology creates permitting complexities and timeline uncertainties.

Resource Uncertainty - Subsurface conditions and heat recovery rates can vary significantly from initial assessments.

Water Management - Water sourcing, treatment, and reinjection require careful environmental management.

Grid Integration - Remote geothermal locations may require transmission infrastructure development.





Funding Opportunities & Incentives

The One Big, Beautiful Bill of 2025 modified many clean energy tax and loan provisions of the Inflation Reduction Act. Geothermal power generation is eligible for the 45Y production tax credit and the 48E investment tax credit.

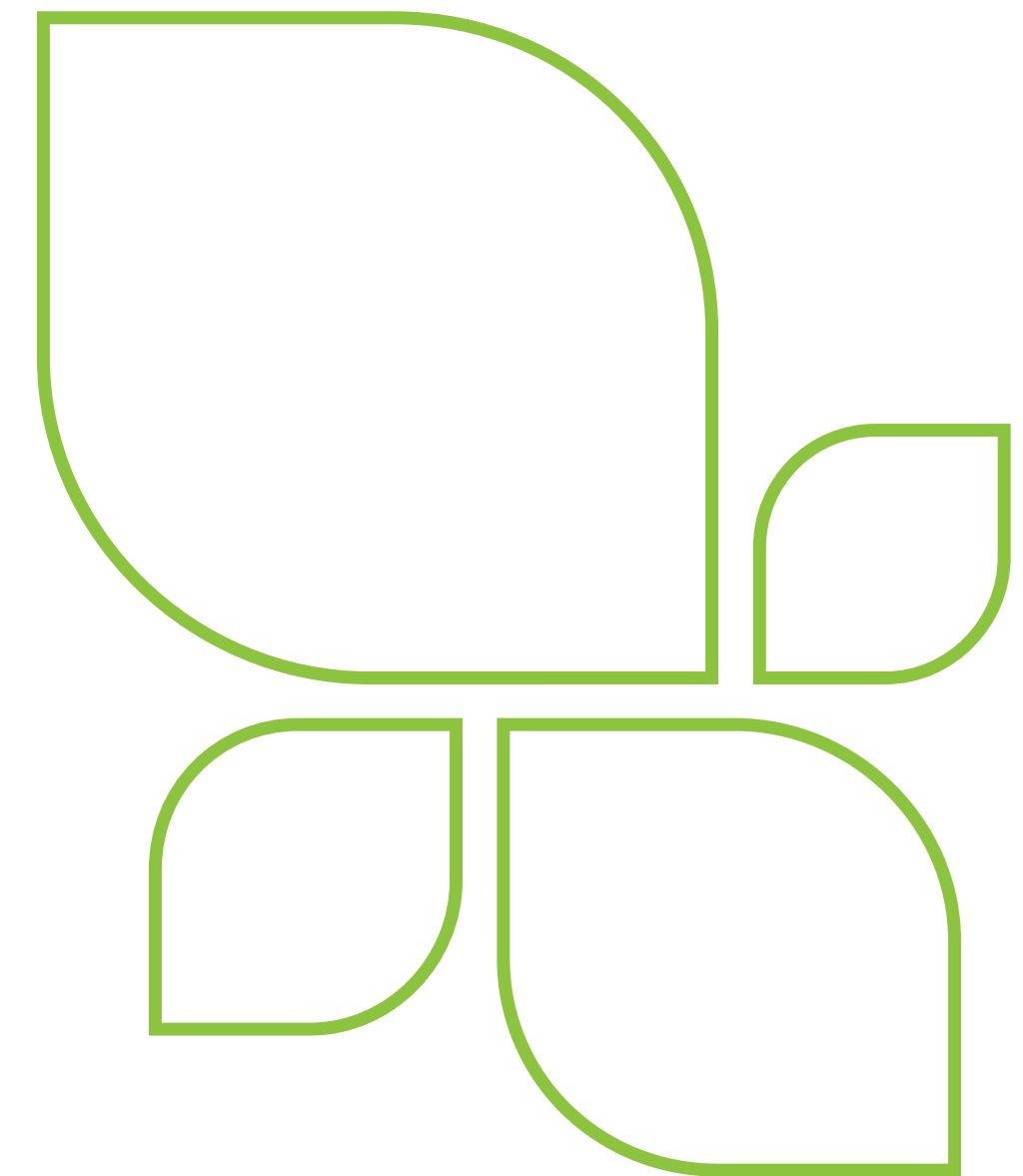
Various state renewable portfolio standards and grants and loans may provide additional support for geothermal development.

The U.S. Department of Energy's Geothermal Technologies Office (GTO) leads federal EGS research and development efforts. The office manages several funding programs:

Enhanced Geothermal Systems Pilot Demonstrations – Multi-year initiative supporting commercial-scale EGS projects across diverse geological conditions.

FORGE (Frontier Observatory for Research in Geothermal Energy) – Utah-based underground laboratory for EGS technology testing and development.

Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE): A multi-year initiative support tech transfer from the oil and gas industry to geothermal.





System Components

DRILLING SYSTEM

EGS projects utilize advanced drilling techniques adapted from oil and gas operations, including horizontal drilling and fracturing, to create deep geothermal wells reaching 7,000–15,000+ feet by bringing water to deeper depths to create steam for industrial use and power generation. Horizontal drilling creates extensive heat exchange areas in hot dry rock formations. Multiple wells may be drilled to create injection and production well pairs. Drilling systems include rotary drill rigs, drilling mud systems, casing programs, and specialized high-temperature drilling equipment.

STIMULATION SYSTEM

Hydraulic stimulation creates fracture networks in hot dry rock to establish fluid circulation pathways between injection and production wells. Stimulation includes high-pressure water injection, chemical additives to enhance fracturing, and proppants to keep fractures open. Controlled stimulation protocols minimize induced seismicity while maximizing heat transfer surface area. Advanced stimulation designs use staged fracturing and selective zone targeting.

RESERVOIR CIRCULATION SYSTEM

The circulation system maintains continuous fluid flow through the enhanced geothermal reservoir. Injection pumps circulate working fluid (typically water) into the reservoir through injection wells. Production pumps extract heated fluid from production wells.

Flow rates are optimized to maximize heat extraction while maintaining reservoir pressure. Circulation systems include high-temperature pumps, flow control systems, and reservoir monitoring equipment.

POWER GENERATION SYSTEM

Surface power generation equipment converts geothermal heat into electricity. Most EGS projects use Organic Rankine Cycle (ORC) systems optimized for moderate temperature geothermal resources (150–200°C). Binary cycle systems use secondary working fluids with lower boiling points than water. Power generation includes heat exchangers, turbines, generators, condensers, and cooling systems. Advanced systems integrate waste heat recovery and hybrid generation technologies.

MONITORING AND CONTROL SYSTEM

Real-time monitoring systems track reservoir performance, well conditions, and surface operations. Distributed fiber optic sensing provides continuous temperature and pressure monitoring along wellbores. Microseismic monitoring networks detect and locate induced seismicity. Surface monitoring includes flow rates, temperatures, pressures, and power generation parameters. Advanced control systems optimize operations and respond to changing conditions.



System Components

COMPONENTS OF TYPICAL ENHANCED GEOTHERMAL SYSTEM

COMPONENT	NAICS CODE	DESCRIPTION	USE
Drilling Rig	333132	Drilling Oil and Gas Wells	Heavy-duty drilling equipment capable of reaching depths of 7,000–15,000+ feet in high-temperature environments
Casing & Tubulars	331210	Iron and Steel Pipe Manufacturing	Steel casing strings protect wellbores and enable fluid circulation in high-temperature geothermal environments
Downhole Pumps	333914	Pump and Pumping Equipment	Submersible and line shaft pumps designed for high-temperature geothermal production
Injection Pumps	333914	Pump and Pumping Equipment	High-pressure surface pumps for reservoir circulation and stimulation operations
Heat Exchangers	333410	Air and Gas Compressors	Shell-and-tube or plate heat exchangers transfer geothermal heat to power generation working fluids
Air-Cooled Condensers	333415	Air Conditioning Equipment	Cools heated working fluid back to liquid to be re-circulated in the closed loop system
ORC Turbine	333611	Turbines and Generator Sets	Organic Rankine Cycle turbines optimized for moderate-temperature geothermal resources

COMPONENT	NAICS CODE	DESCRIPTION	USE
Wellhead Equipment	333132	Oil and Gas Equipment	Christmas trees, wellheads, and production equipment for geothermal wells
Stimulation Equipment	333132	Oil and Gas Equipment	Hydraulic fracturing equipment for reservoir enhancement
Fiber Optic Sensing	237130	Electronic Equipment	Distributed temperature and strain sensing systems for real-time wellbore monitoring
Microseismic Monitoring	334519	Measuring Devices	Seismometer networks for induced seismicity detection and location
Control Systems	334512	Electronic Equipment	Automated control systems for reservoir management and power generation
Piping Systems	331210	Pipe Manufacturing	High-temperature piping for geothermal fluid transport
Electrical	335311	Power Distribution Equipment	Transformers, switchgear, and transmission equipment for power delivery



ESG Developers & Manufacturers

Fervo Energy - Leading EGS developer using horizontal drilling and fiber optic monitoring to create next-generation geothermal systems. Currently developing Cape Station project in Utah and has secured major corporate power purchase agreements.

Eavor Technologies - Canadian company developing closed-loop geothermal systems that eliminate the need for hydraulic stimulation through advanced drilling techniques.

Sage Geosystems - Texas-based company developing EGS projects and geothermal energy storage systems using advanced drilling and completion techniques.

Ormat Technologies - Established geothermal developer expanding into EGS with proven power generation equipment and project development expertise.

Gradient - Colorado-based geothermal developer focused on dual-purpose or converted oil and gas /wells paired with geothermal production.

Greenfire - California-based geothermal developer developing projects in conventional and unconventional geothermal reservoirs.

Baker Hughes - Oil and gas services company providing drilling, completion, and monitoring services for EGS projects.

Halliburton - Energy services company offering drilling, stimulation, and monitoring technologies adapted for geothermal applications.

Schlumberger - Global energy technology company providing integrated drilling, completion, and reservoir monitoring services for EGS development.



ESG Trade Associations & Resources

Geothermal Rising – National trade organization representing the geothermal industry, including EGS developers, equipment manufacturers, and service providers.

Project Innerspace Foundation – Global non-profit focused on engaging the oil and gas industry for geothermal production.

National Renewable Energy Laboratory (NREL) – Conducts extensive geothermal research including EGS technology development, resource assessment, and economic analysis.

Geothermal Technologies Office (GTO) – U.S. Department of Energy office leading federal EGS research, development, and deployment programs.

Utah FORGE – U.S. Department of Energy's underground laboratory for EGS research and technology testing located in Utah.

Western Governors' Association – State coalition of governors, with a “Heat Beneath Our Feet” initiative promoting geothermal development through policy initiatives and interstate coordination.

Groundwater Protection Council – Multi-state association of state water and oil and gas regulators, focused on best practices and regulatory systems for underground injection control wells.

Interstate Oil and Gas Compact Commission – Congressionally chartered multi-state association of state oil and gas regulators.

Society of Petroleum Engineers – A global professional organization dedicated to the advancement of knowledge and technology in the oil and gas sector.



Other Types of Geothermal Energy Development

Conventional Geothermal – The extraction of existing high pressure, high temperature steam from naturally occurring water and hot rock.

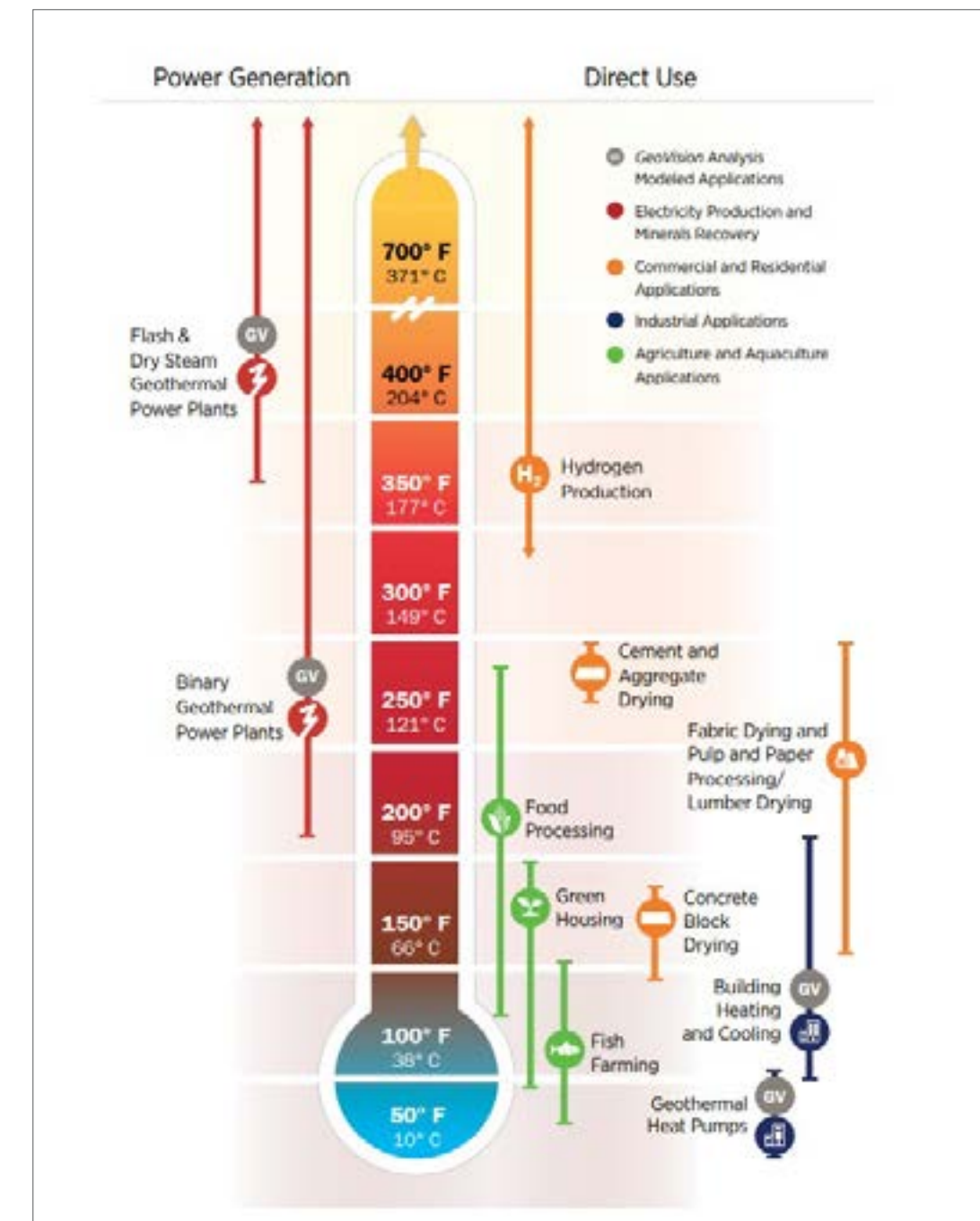
District Heating & Thermal Energy Networks – Campus or neighborhood-scale systems with multiple buildings connected through shared pipes for heating and cooling needs, with the energy provided by geothermal or waste heat.

Direct Use – The direct use of geothermal heat and water for industrial processes, such as aquaculture and commercial agriculture production.

Ground Source Heat Pumps – Shallow well systems, used for building HVAC, that uses the earth as a heat source and sink by circulating fluid to introduce or withdraw heat from a building.

Geoexchange Systems & Subsurface Energy Storage – The use of the earth for the temporary storage of heat or water at pressure, for later use in building HVAC or power generation.

Lithium & Rare Earth Extraction – The extraction of rare earths, such as lithium, from the circulation of geothermal brines from subsurface geologies.



Source: DOE Geovision Report (2019)
<https://www.energy.gov/sites/default/files/2019/06/f63/GeoVision-full-report-opt.pdf>



United States – Geothermal Resource Potential

The United States contains vast Enhanced Geothermal Systems potential, with resources available in most states when EGS technology is applied. Unlike conventional geothermal resources limited to specific geological regions, EGS can access heat resources at depths of 3–10 km across much of the country.

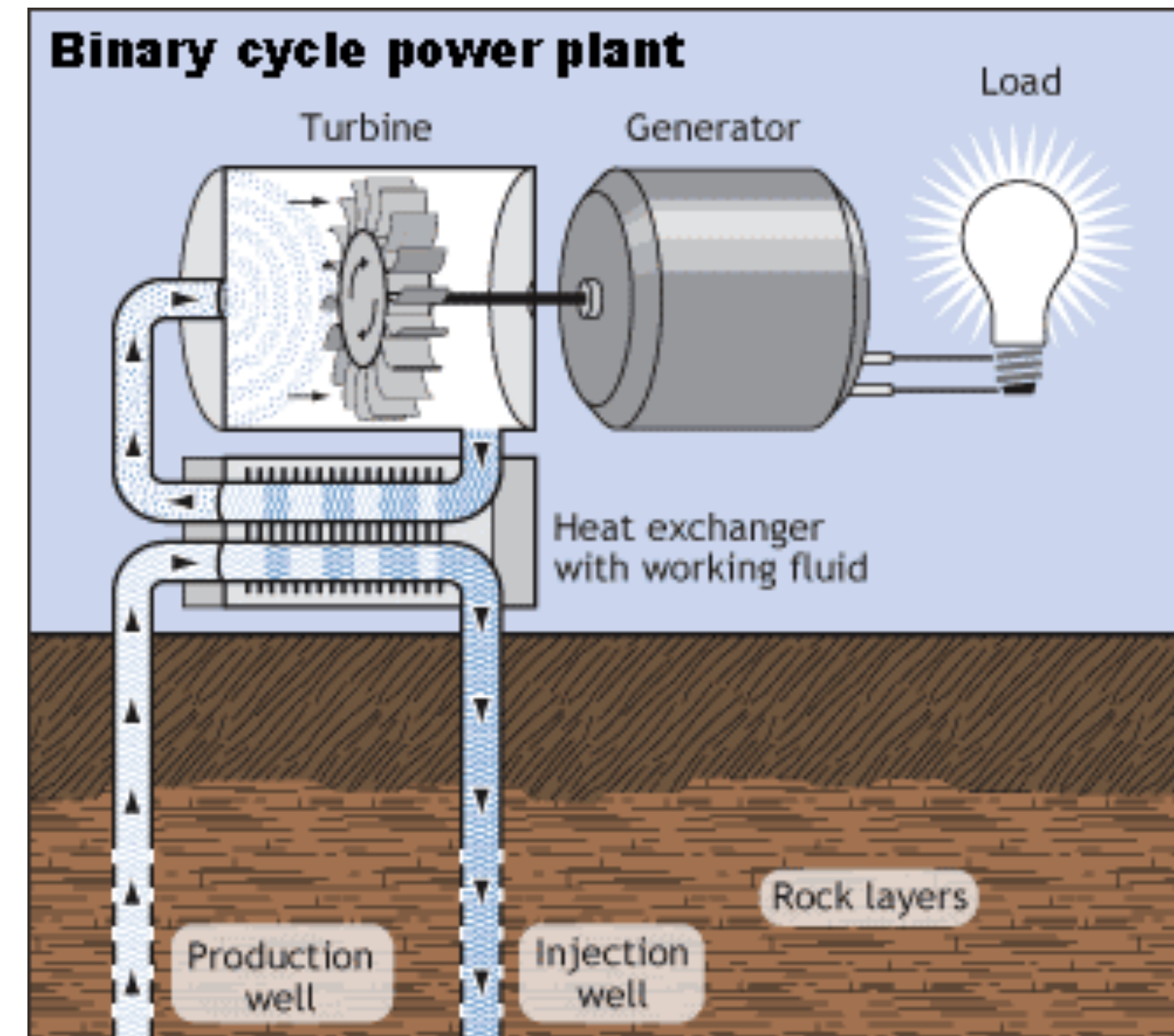
High-Temperature Resources (>150°C at 3–6 km depth):

- Western United States: Nevada, California, Utah, Idaho, Oregon, Washington
- Southwest: Arizona, New Mexico, Colorado
- Alaska: Significant high-temperature resources

Moderate-Temperature Resources (100–150°C at 3–6 km depth):

- Great Plains: Texas, Oklahoma, Kansas, Nebraska
- Southeast: Louisiana, Arkansas, Mississippi
- Northeast: New York, Pennsylvania, West Virginia

Total Technical Potential: DOE estimates suggest EGS could provide over 500 GW of baseload generation capacity in the United States.



Source: US DOE (2022)
<https://www.eia.gov/energyexplained/geothermal/geothermal-power-plants.php>



Links

ESG Developers and Manufacturers

- <https://www.fervoenergy.com>
- <https://www.eavor.com>
- <https://www.sagegeosystems.com>
- <https://www.ormat.com>
- <https://www.gradientgeothermal.com>
- <https://www.greenfireenergy.com>
- <https://www.bakerhughes.com/geothermal-solutions>
- <https://www.halliburton.com/en/low-carbon-solutions/geothermal>
- <https://www.slb.com/products-and-services/scaling-new-energy-systems/geothermal>

Trade Associations and Resources

- <https://www.geothermal.org>
- <https://projectinnerspace.org>
- <https://www.nrel.gov/geothermal>
- <https://www.energy.gov/eere/geothermal/geothermal-technologies-office>
- <https://www.utahforge.energy>
- <https://westgov.org/policy/chair-initiatives-overview/the-heat-beneath-our-feet>
- <https://www.gwpc.org/>
- <https://oklahoma.gov/iogcc.html>
- https://www.spe.org/en/focus/geothermal/?gad_source=1

Federal Resources

- <https://www.energy.gov/eere/geothermal/enhanced-geothermal-systems-egs-pilot-demonstrations>
- <https://docs.nrel.gov/docs/fy19osti/71843.pdf>
- <https://www.usgs.gov/centers/geology-energy-and-minerals-science-center/science/geothermal-energy>
- <https://openei.org/wiki/GeoBridge>



Energy & Manufacturing in Appalachia Program

This energy overview research and report was created under the Energy & Manufacturing in Appalachia (EMA) program made possible with grant funding from the Appalachian Regional Commission. EMA provides technical assistance and business support to small and medium manufacturers and enterprises seeking to expand business, production and jobs in the energy supply chains. Energy is a big expense for manufacturing companies. EMA helps companies save money with energy efficiency and emissions reductions.

The EMA program supports Appalachia in 156 counties of Maryland, New York, Ohio, Pennsylvania, and West Virginia. This program was established to help small and medium manufacturers be a part of this Energy Economy. This program is managed by Manufacturing Extension Partnership (MEP) organizations from five Appalachian states. The activities and intended outcomes of EMA align with the National Institute of Standards and Technology (NIST) MEP and its mission to enhance the productivity and technological performance of U.S. manufacturing.

Learn more about the Energy & Manufacturing in Appalachia program by visiting: <https://www.wemakeithere.org/energy/> and join the EMA LinkedIn group.

Contact EMA Program Manager, Tom Reed, directly at Tom@WeMakeItHere.org and (412) 918-4269 with any questions or assistance.