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2025 U.S. Geothermal Market Report

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GEOTHERMAL RISING

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All report figures by National Laboratory of the Rockies, unless noted otherwise.

List of Acronyms

AI	artificial intelligence
ARPA-E	Advanced Research Projects Agency–Energy
ATB	Annual Technology Baseline
BLM	Bureau of Land Management
BTES	borehole thermal energy storage
CAPEX	capital costs
CBECS	Commercial Building Energy Consumption Survey
CH	conventional hydrothermal
CLG	closed-loop geothermal
CO_2	carbon dioxide
CPUC	California Public Utilities Commission
CTR	Controlled Thermal Resources
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOI	U.S. Department of the Interior
ECM	energy conservation measure
EER	energy efficiency ratio
EGS	enhanced geothermal system
EIA	U.S. Energy Information Administration
ESPC	Energy Service Performance Contract
FEMP	Federal Energy Management Program
FORGE	Frontier Observatory for Research in Geothermal Energy
GDU	geothermal direct use
GeoTES	geological thermal energy storage
GETEM	Geothermal Electricity Technology Evaluation Model
GHP	geothermal heat pump
GTO	Geothermal Technologies Office
GWe	gigawatts-electric
GWth	gigawatts-thermal
HVAC	heating, ventilating, and air conditioning
IEA	International Energy Agency
IDIQ	Indefinite Delivery, Indefinite Quantity
IGSHPA	International Ground Source Heat Pump Association
IRA	Inflation Reduction Act
IRENA	International Renewable Energy Association
IRS	Internal Revenue Service
ITC	Investment Tax Credit
km	kilometer
kWe	kilowatt-electric
LCOE	levelized cost of energy
LCOH	levelized cost of heat
MMBtu	million British thermal units
MWe	megawatt-electric
MWh	megawatt-hour
MWth	megawatt-thermal
NEPA	National Environmental Policy Act
NLR	National Laboratory of the Rockies
NYSERDA	New York State Energy Research and Development Authority
ORC	organic Rankine cycle
ORNL	Oak Ridge National Laboratory
O&M	operation and maintenance
PNNL	Pacific Northwest National Laboratory
PPA	power purchase agreement
PTC	Production Tax Credit
PURPA	Public Utilities Regulatory Policy Act
PV	photovoltaic
R&D	research and development
RECS	Residential Energy Consumption Survey
ReEDS	NLR's Regional Energy Deployment System
reV	NLR's Renewable Energy Potential model
SAM	NLR's System Advisor Model
TEN	Thermal Energy Network
TWe	terawatt-electric
USFS	United States Forest Service

Executive Summary

The *2025 U.S. Geothermal Market Report* updates and expands on the *2021 U.S. Geothermal Power Production and District Heating Market Report*, also referred to as the 2021 Geothermal Market Report (Robins et al., 2021). This report was developed by the National Laboratory of the Rockies (NLR), formerly known as NREL, a national laboratory supporting the U.S. Department of Energy (DOE), and Geothermal Rising, a professional and trade association for the geothermal industry, with support from the International Ground Source Heat Pump Association (IGSHPA), a professional organization for advancing geothermal heat pump technologies. The intent of this work is to provide policymakers, developers, researchers, engineers, financiers, and other stakeholders with an update on the U.S. geothermal market.

This report discusses updates since 2020 regarding technology, cost trends, and market activities for both geothermal power production as well as geothermal heating and cooling systems. A notable difference since the 2021 Geothermal Market Report is the inclusion of geothermal heat pumps (GHPs) for both single building and district heating and cooling applications. This section provides a summary of key findings—first for geothermal power generation, then for geothermal heating and cooling systems, and finally for emerging opportunities.

Production well at Blue Mountain Geothermal Plant in Humboldt County, Nevada. *Photo by Dennis Schroeder, National Laboratory of the Rockies 48293*

Geothermal Power Generation Market: Key Findings

Steady Increase in Installed Capacity, Concentrated in Western States

Geothermal power installed nameplate capacity as of 2024 is 3.969 gigawatts-electric (GWe) (3,969 megawatts-electric [MWe]), an 8% increase from 3.673 GWe (3,673 MWe) in 2020. This net increase comprises 246 MWe of new installed capacity, 132 MWe of capacity expansions/additions, and 82 MWe in plant retirements between 2020 and June 2024 (Figure ES-1). Correspondingly, summer and winter net capacities have also risen from 2.56 GWe and 2.96 GWe in 2019 to 2.69 GWe and 3.12 GWe in 2023, respectively. Two operators, Ormat and Calpine, continue to comprise the majority of U.S. geothermal power plant ownership and operation. Together they account for 69% of total installed capacity and 61% of all operating geothermal plants in the United States.

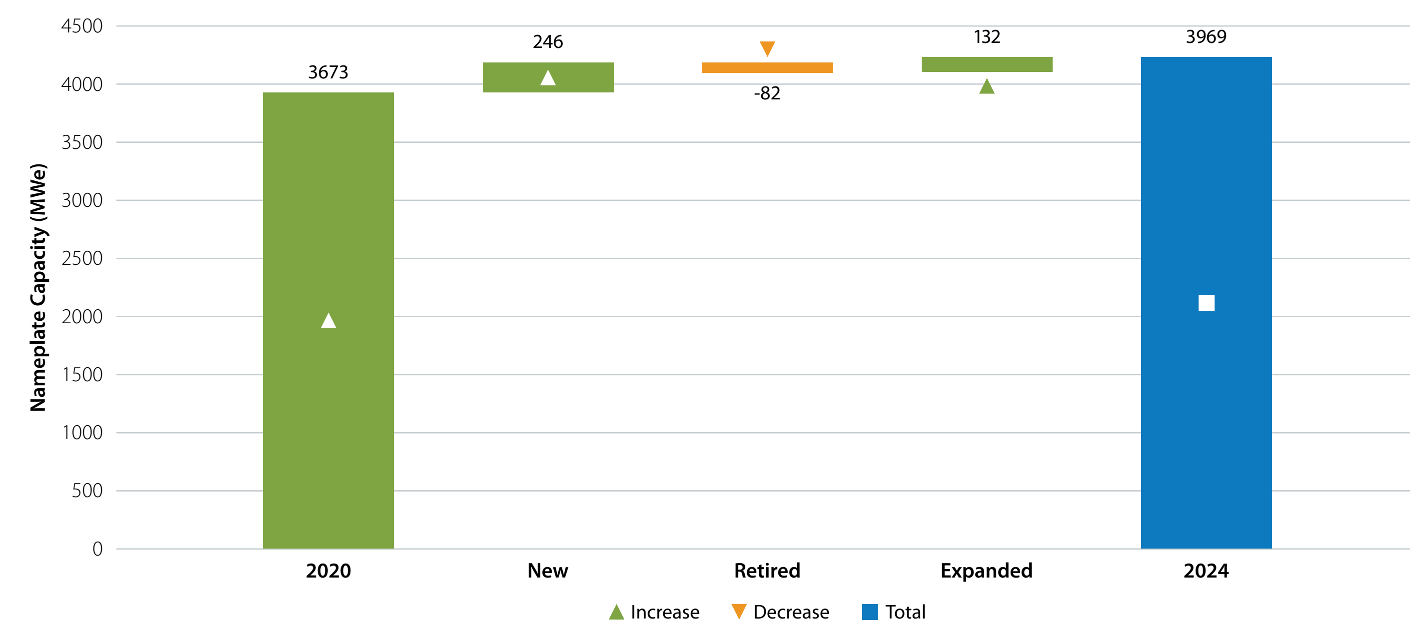

Figure ES-1. Geothermal nameplate capacity growth in the United States since 2021 Geothermal Market Report. *Note that "new" refers to nine new plants that have come online, "retired" represents six plants that are no longer operational, and "expanded" includes plants that have reported changes in their capacity.*

Geothermal power plants are almost entirely concentrated in the western United States (see Figure ES-2). This geographical region consists of several Known Geothermal Resource Areas (e.g., The Geysers), with high thermal gradients, heat flow, and permeability, that have been historically explored and developed for power production. California hosts 53 of the 99 geothermal power plants[1] in the country, with a total installed nameplate capacity of 2.87 GWe (2,868 MWe, 72% of the U.S. total). Nevada, with significant resource potential, is second with 32 power plants and an installed nameplate capacity of 892 MWe. Other states with geothermal power installed include Oregon and Utah with four plants each, Hawai'i and Alaska with two plants each, and Idaho and New Mexico with a single plant each.[2]

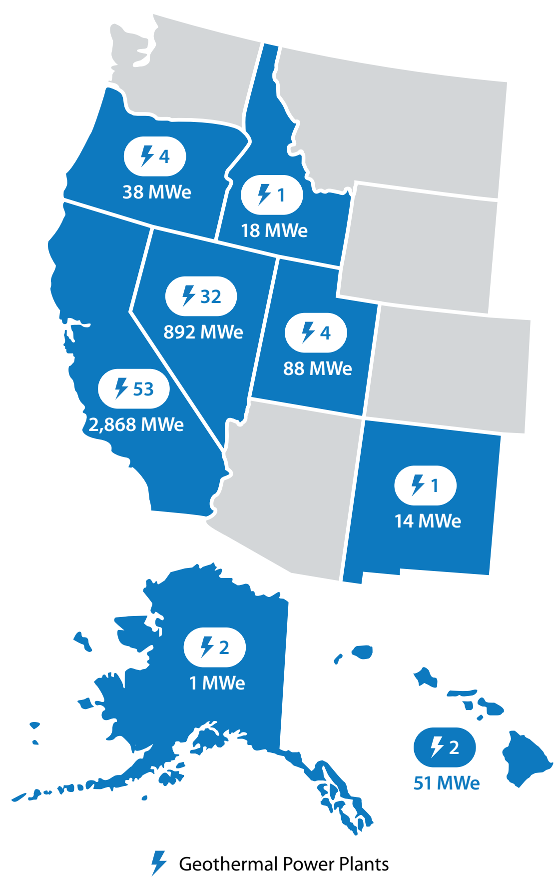

Figure ES-2. Distribution and installed nameplate capacity of geothermal power plants in the United States as of June 2024. *Data from EIA (2024a, 2024d). In the power plant totals for each state, a single plant is described by the installation year (Appendix B) as it can consist of one or more generating units installed over years. Some plants (e.g., Puna in Hawai'i and McGinness Hills in Nevada) have been expanded in subsequent years after the first unit was installed. These are treated as separate plants as shown in Appendix B. This does not include planned plants that are not yet operational.*

New Power Purchase Agreements and Projects Under Development Indicate Accelerated Interest by Utilities, Corporations

The rise in recent power purchase agreements (PPAs)—26 since the 2021 Geothermal Market Report, as of June 2025—is an indicator that the geothermal power sector is primed for substantial growth. In total, these represent more than 1.6 GWe (1,642 MWe) of new capacity commitments to be developed in the near term (see Figure ES-3 for a map of new developments). The California Public Utilities Commission (CPUC) released a procurement order in 2021 that contributed to the increase in PPAs (CPUC, 2021). NLR analysis in this report shows that the order has led to the signing of at least 616 MWe in PPAs between geothermal developers and load-serving entities in California as of June 2025. This order also awarded credits to imports of firm (i.e., "always on") power from other states, resulting in PPAs signed between California purchasers and geothermal developers in Nevada and Utah.

Next-generation geothermal systems[3] account for 60% of geothermal PPAs signed between 2021 and July 2025. The first of these PPAs was signed in 2022 between Fervo Energy and Google, through NV Energy, for 3.5 MWe of power produced from an enhanced geothermal system (EGS) project. As of June 2025, utilities have procured (or agreed to procure) 984 MWe of next-generation geothermal power capacity across California (439 MWe), Nevada (135 MWe), New Mexico (150 MWe), Texas (110 MWe), and an undisclosed location east of the Rocky Mountains (150 MWe) through 11 PPAs.

Overall, the number of geothermal power projects under development has increased from 54 to 64 since 2020. This is based on data gathered through industry survey respondents as of June 2024 from major geothermal developers and operators, and compares data from companies that existed in both 2020 and 2024. Ormat continues to lead in conventional commercial geothermal development, with 37 projects under development. Fervo Energy, with four developing projects, and Sage Geosystems and Eavor, with two projects each, are spearheading commercial next-generation geothermal.

Major R&D and Commercial Advancements in Next-Generation Power Technologies

DOE's Frontier Observatory for Research in Geothermal Energy (FORGE) site near Milford, in Beaver County, Utah, has

[1] Multiple geothermal power plants can be situated in a Known Geothermal Resource Area. For example, 17 of the 53 plants in California are within The Geysers Known Geothermal Resource Area.

[2] A single plant is described by the installation year (Appendix B) as it can consist of one or more generating units installed over years. Some plants (e.g., Puna in Hawai'i and McGinness Hills in Nevada) have been expanded in subsequent years after the first unit was installed. These are treated as separate plants as shown in Appendix B.

[3] The term "next-generation geothermal systems" refers to technologies that enable geothermal energy to be harnessed in low to ultra-low permeability formations through advanced drilling and/or stimulation techniques. This technology category currently includes enhanced geothermal systems and closed-loop geothermal systems.

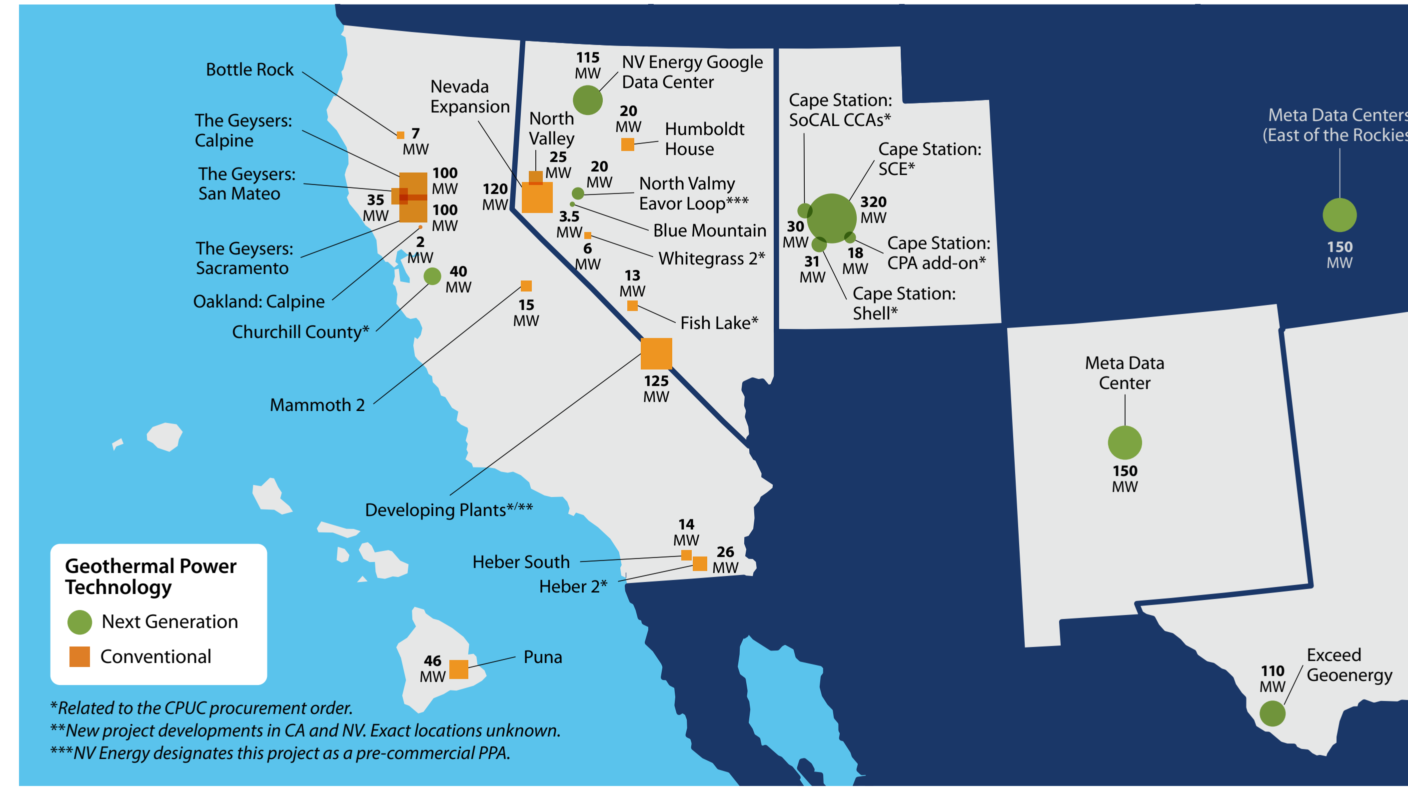

Figure ES-3. New geothermal power project developments within PPAs signed between 2021 and July 2025, including those related to the 2021 CPUC procurement order. *Data from multiple sources; see Table 3 for more information. Note that CCA stands for Community Choice Aggregator, SCE stands for Southern California Edison, and CPA stands for Clean Power Alliance.*

been largely successful in showing a replicable process for developing EGS reservoirs. FORGE has drilled seven wells, and has achieved notable improvements in drilling performance, including reduction in on-bottom drilling hours—110 hours for a well in 2023 compared to 310 hours for a well in 2020 (Dupriest and Noynaert, 2024).

In 2023, Fervo Energy recorded the first commercial-scale EGS drilling and reservoir development pilot in the United States adjacent to the Blue Mountain Geothermal Plant in Nevada (Norbeck and Latimer, 2023). Fervo Energy has an additional four projects in development, including a first-of-a-kind large-scale 500-MWe (100 MWe Phase 1 and 400 MWe Phase 2) commercial EGS project underway at their Cape Station site near Utah FORGE in Beaver County, Utah (Fervo Energy, 2024a).

The development of closed-loop geothermal (CLG) systems is steadily advancing. In 2022, Eavor Technologies drilled the first two-leg multilateral deep geothermal well in the U.S. in New Mexico. In that project, Eavor drilled a single vertical well with a sidetrack to a true vertical depth of 18,000 ft and rock temperature of 250°C, a first in the U.S. geothermal industry (Brown et al., 2023).

EGS Costs Decreasing, Conventional Hydrothermal Costs Holding Steady

The levelized cost of energy (LCOE) for EGS is declining (Figure ES-4) and is projected to hit levels of 2024 flash hydrothermal LCOE within the next decade based on the 2024 Annual Technology Baseline (ATB) Moderate Scenario (NLR, 2024). The latest outcomes from Fervo's drilling, stimulation, and well testing activities at its Cape Station site have bolstered this developing projection.

As seen in Figure ES-4, the LCOE for conventional hydrothermal systems has been relatively flat since the 2021 Geothermal Market Report and has hovered between \$63–74 per megawatt-hour (MWh) for flash-based plants and \$90–110 per MWh for binary plants. However, these LCOEs are competitive with the geothermal PPA prices compiled in this report.

Investment in Next-Generation Geothermal Technologies Is Accelerating

Companies at the forefront of developing and commercializing next-generation geothermal technologies have raised more than \$1.5 billion in private capital since 2021. According to recent data gathered by NLR, EGS and CLG technology companies and startups have brought

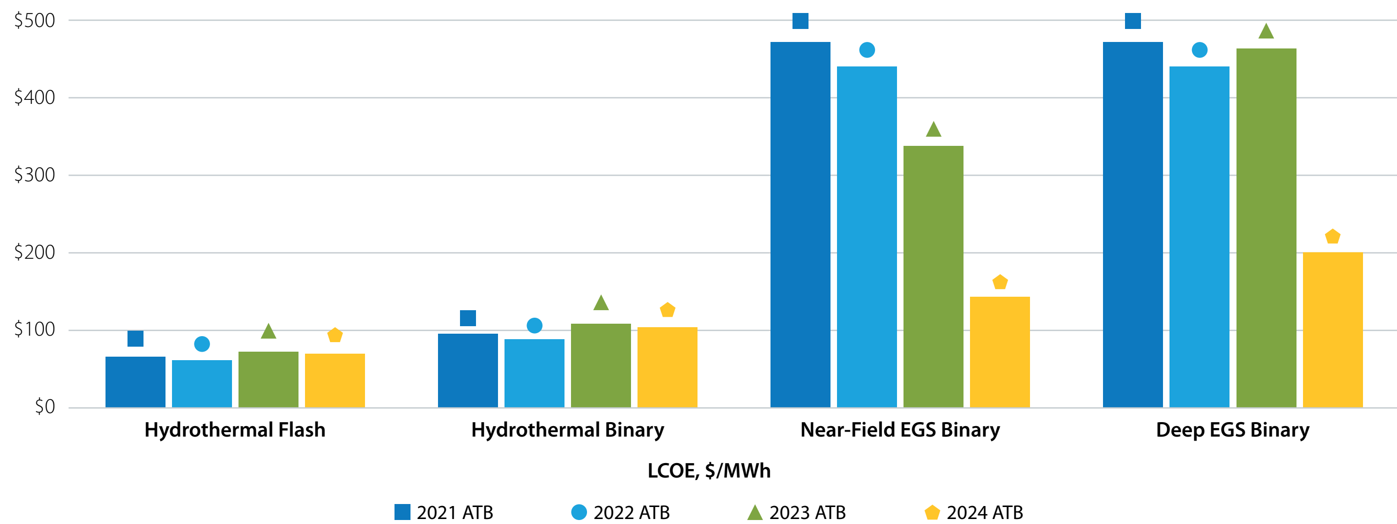

Figure ES-4. The levelized cost of energy for geothermal power technologies from the 2021 ATB to the 2024 ATB. *All costs are in 2022 dollars (the 2024 ATB base year).*

in $990 million and $604 million, respectively, in capital investment between 2021 and mid-2025. Within this period, Fervo Energy and Eavor Technologies raised additional amounts—$642 million and $387 million in equity investments, respectively (Fervo Energy, 2024a, 2024b, 2024c, 2025; Eavor Technologies, 2024a). Technology advances are helping to increase attractiveness of next-generation geothermal for debt financing. Fervo has secured $331 million in debt financing through various loan facilities to finance their Cape Station project in Utah, and Eavor received $142 million in loans in 2024 (Fervo Energy, 2024b, 2025; Eavor Technologies, 2024a; 2024b).

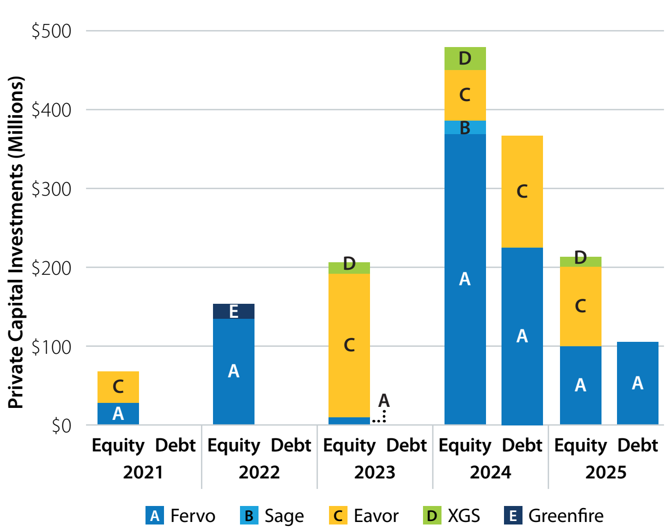

Figure ES-5. Private capital investments in next-generation geothermal developers between 2021 and June 2025. *Sources: Fervo Energy (2024a, 2024b, 2024c, 2025), Business Wire (2024a; 2024b; 2025a), Eavor Technologies (2024a; 2024b), and Pitchbook (2025).*

Domestic Geothermal Potential Is Abundant, Including on Public Lands

Based on recent NLR analysis, the estimated average EGS resource potential is 27 terawatt-electric (TWe) to 57 TWe within 1- to 7-km depth across the continental United States (Menon et al., 2025). NLR also estimates 4.35 TWe of EGS resources are within Bureau of Land Management (BLM) and United States Forest Service (USFS) land (Martinez Smith et al., 2024). Further analysis of these results indicates a smaller amount of resource potential that is considered economically developable, including 1.1% (47.8 GWe) of EGS resources. As of June 2025, geothermal projects on public lands (managed by the BLM as part of the Federal mineral estate) total 2,600 MWe of nameplate capacity, with 756 MWe added since 2000 (EIA, 2024a; Ormat, 2024a). As of 2023, 51 geothermal power plants are in operation on BLM-managed lands (BLM, 2023b). In 2022, geothermal power plants on BLM-managed lands generated 11.1 terawatt-hours (TWh) of electricity (EIA, 2024a, 2024b, 2024c).

States Incentivize Geothermal Power Projects

As of December 2025, there were 29 U.S. states with incentive policies for geothermal power including grants, rebates, tax incentives, and other financial incentives (e.g., reduced cost and/or free application fees for permit processing). A total of 17 states and D.C. have policies that encourage geothermal electricity production, including tax credits. Furthermore, 42 states and D.C. have existing regulatory policies that include geothermal power, which include energy and efficiency standards, net metering, and/or interconnection standards.

Geothermal Heating and Cooling Market: Key Findings

Geothermal Heat Pumps Are Reliable, Highly Efficient, and Available Across the Country

The GHP market is an established energy market for residential and commercial building heating and cooling. GHPs are used across all geographical and climatic regions in the United States, according to census track data from the Energy Information Administration (EIA) (Figure ES-6) and corroborated by historical well permit data collected by NLR for single building GHP installations (Pauling, Podgorny, and Akindipe, 2025).[4]

GHP systems have seen increased adoption across various sectors, including residential, commercial, and industrial applications. Residential use has been a major focus as homeowners seek energy-efficient options. Based on extrapolation of data from the Residential Energy Consumption Survey (RECS) and the Commercial Building Energy Consumption Survey (CBECS), an estimated 1.27 million residential housing units and 27,300 commercial buildings across the United States have GHP installations. In the residential sector, Florida, Tennessee, and North Carolina are estimated to have the highest number of housing units with GHPs.

Incentives Help Offer Consumers Energy Options

As of December 2025, 34 states and D.C. have incentive policies for GHPs. These include grants, rebates, tax incentives, and other financial incentives. In addition, eight states have policies that encourage GHP adoption. 23 states and D.C. have existing regulatory policies for GHPs. As of July 2025, at the federal level, homeowners were eligible for a 30% tax credit on GHPs as part of the Inflation Reduction Act (IRA) Residential Energy Credit (Section 25D of U.S. Code 2025a), however, the property must have been placed in service prior to December 31, 2025. As of July 4, 2025, an exemption to the IRS policy of limited-use property doctrine was created for geothermal systems where they may now be leased by a third-party, including to residential customers (Section 50 of U.S. Code, 2025c). The IRA also includes a base 6% tax credit for commercial building owners installing GHPs (Section 48 of U.S. Code, 2025b).

GHPs Offer Secure, Reliable Support for U.S. Grid Infrastructure

GHPs can offer up to $1 trillion in value in the form of avoided grid infrastructure build-out costs to the future U.S. grid. Oak Ridge National Laboratory estimates that GHP deployment in 68% of the total existing and new building floor space in single-family homes in the continental United States by 2050 would provide multiple benefits to the electric grid, including up to $306 billion reduction in electric power system costs and up to $606 billion savings in wholesale electricity marginal costs (Liu et al., 2023). Mass GHP deployment is estimated to have the potential to reduce required additional annual generation by 585–937 TWh and power and storage capacity by 173–410 GW. Mass GHP deployment is also expected to alleviate the need for transmission build outs by 3.3–65.3 TW-miles.

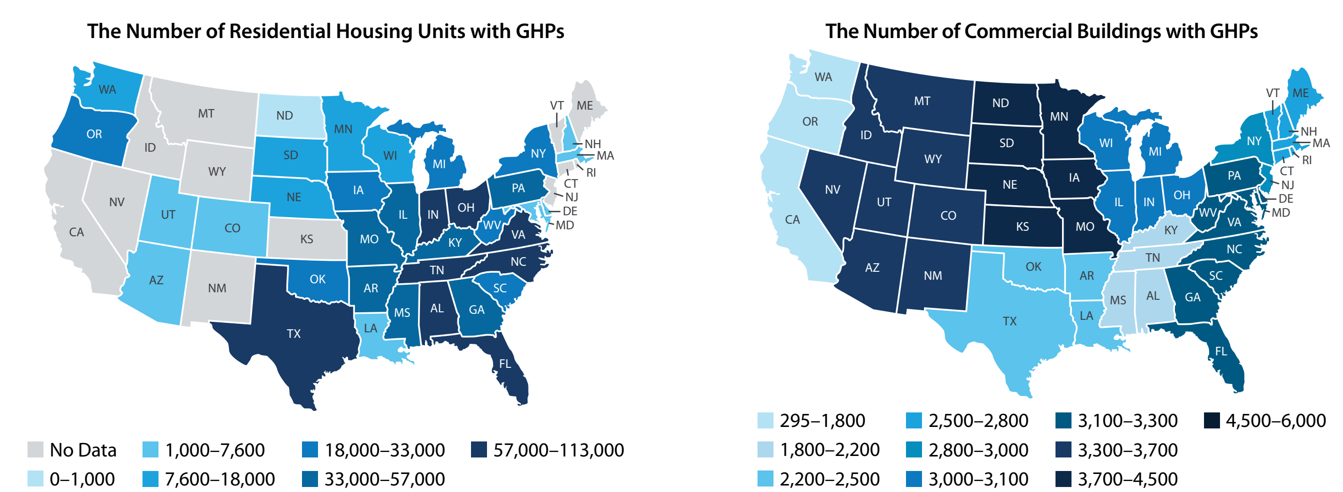

Figure ES-6. GHP installations in the United States. *(left) State-level distribution of residential housing units with GHPs estimated using EIA's 2020 RECS data (EIA, 2023b). (right) Census division-level distribution of commercial buildings with GHPs using 2018 CBECS data (EIA, 2023a).*

[4] These data are available on the Geothermal Data Repository: https://gdr.openei.org/submissions/1755.

Thermal Energy Networks Are a Growing Market for District Heating and Cooling

Accelerating interest in energy efficiency in buildings from neighborhood to city scale has spurred the rise of Thermal Energy Networks (TENs). A geothermal TEN is a fifth-generation geothermal district heating and cooling system with decentralized GHPs connected to a shared distribution loop. States like California, Colorado, Maryland, Massachusetts, Minnesota, New York, Vermont, and Washington have enacted regulations and announced programs that specifically address the need for geothermal TENs within energy utility service territories (Varela and Magavi, 2024).

In 2024, the natural gas utility Eversource Energy commissioned a first-of-its-kind U.S. utility-owned geothermal TEN pilot in Framingham, Massachusetts. The Framingham project consists of an ambient temperature loop that connects decentralized GHPs in 36 buildings—including 24 residential and five commercial buildings—to three borehole fields (Eversource, 2025). The Framingham pilot project serves as a first example and path forward for the rapidly growing national interest by natural gas utilities and state regulatory agencies in developing TEN projects within their service territories and jurisdictions.

Geothermal Direct Use in the United States Cuts Across Multiple End Uses

Based on updated data compiled by NLR beyond the 2021 Market Report (Robins et al., 2021), there were close to 500 geothermal direct-use (GDU) installations (by end-use application) in the United States as of October 2024. Of these, GDU for heating resorts and pools accounts for the largest portion (59%) with 281 installations, followed by space heating (77), aquaculture (47), greenhouse (37), district heating (25), and other (15) applications, including dehydration, snow melting, irrigation, and gardening. With 89 installations, California has the most GDU installations in the United States.

Emerging Opportunities: Key Findings

Geothermal As Part of U.S. Energy Security and Independence

From a power generation perspective, geothermal energy can strengthen the electric grid and provide resilience against extreme weather, power outages, and cyberattacks. These benefits likely contributed to the greenlighting of geothermal energy projects within multiple U.S. Department of Defense (DoD) installations. Specifically, DoD awarded six projects between September 2023 and April 2024 to explore the potential of conventional and next-generation geothermal technologies in a total of seven installations. The DoD locations (and awardees) include Joint Base San Antonio in Texas (Eavor), Fort Wainwright in Alaska (Teverra), Mountain Home Air Force Base in Idaho (Zanskar), Fort Irwin in California (Zanskar), Naval Air Station Fallon in Nevada (Fervo), Naval Air Facility El Centro in California (GreenFire Energy), and Fort Bliss in Texas (Sage Geosystems) (Defense Innovation Unit, 2023, 2024). In August 2025, the DoD installations were expanded to include the Marine Corps Air Ground Combat Center Twenty-Nine Palms and the Sierra Army Depot, both in California (GreenFire Energy), the Naval Air Station Corpus Christi in Texas (Sage Geosystems), and the Army's White Sands Missile Range in New Mexico (Teverra) (Defense Innovation Unit, 2025). In a separate effort, the U.S. Department of the Air Force awarded Sage Geosystems a $1.9-million grant in September 2024 for a pilot demonstration of their next-generation technology at an off-site test well in Starr County, Texas (Bela, 2024).

Among heating and cooling technologies, geothermal is a resilient and reliable option. As a resilient energy source, it is not affected by supply chain disruptions and energy price fluctuations like conventional heating fuels. As a reliable energy source, the resource capacity of geothermal for heating and cooling through GHPs is not directly affected by changes in surface weather conditions. These unique attributes have been found useful for various building types across the U.S., including federal buildings. Based on recent analysis, 24 separate GHP projects were awarded in federal buildings between 2001 and 2014 across the country, leading to energy and maintenance cost savings (Shonder and Walker, 2024).

Data Center Support Is a Key Opportunity Area for Geothermal Power

Data center load growth has tripled over the past decade and is projected to double or triple by 2028 (Shehabi et al., 2024). Geothermal energy has the potential to play a key role in meeting the rapidly growing power demands of artificial intelligence (AI)-driven data centers by providing firm, reliable energy as well as critical opportunities to significantly reduce peak data center cooling demands through underground thermal energy storage. Major technology companies have already turned to geothermal energy to power their operations—Meta signed a PPA in 2024 with Sage Geosystems for up to 150 MWe of geothermal power to support its U.S. data centers (Meta, 2024) and another 150 MWe PPA with XGS to support data centers in New Mexico (Business Wire, 2025b). Similarly, Google expanded its partnership with Fervo Energy and NV Energy in 2024 beyond the initial 3.5 MWe agreement, securing 115 MWe of geothermal energy to supply its Nevada data centers (Hanley, 2024).

Superhot Geothermal Could Boost Geothermal Well Output

Superhot/supercritical geothermal has the potential to deliver 5–10 times the thermal energy output per well compared to conventional geothermal systems (CATF, 2025). Estimates suggest that harnessing heat from superhot resources shallower than 10 kilometers (km)—accessible with existing drilling technology—could supply up to 50% of current global electricity demand (Kiran et al., 2024). DOE's Geothermal Technologies Office (GTO) funded research in this area, including a project to de-risk superhot exploration and one to demonstrate superhot EGS on the western flank of Oregon's Newberry Volcano (GTO, 2024a).

Hybrid Plants, Geological Thermal Energy Storage, and Co-Production Could Offer Additional Avenues for Flexible Generation and Grid Stability

In addition to providing flexible generation and grid stability, geothermal can be used as a balancing resource. For instance, hybrid plants integrating geothermal with solar photovoltaic or concentrating solar thermal technologies can provide baseload capacity and peaking power. Examples of this include Cyrq Energy's Patua project, Ormat's Tungsten Mountain project, and Ormat's (formerly Enel's) Stillwater project.

Another growing application of geothermal is geological thermal energy storage (GeoTES). GeoTES converts sedimentary reservoirs (e.g., depleted oil and gas reservoirs) to long-duration energy storage systems. There are not yet any active GeoTES plants in the United States, but GTO and DOE's Solar Energy Technologies Office previously separately selected for negotiation two demonstration projects in this space. The first project aims to develop a 100-kilowatt-electric (kWe) demonstration power plant with more than 12 hours of GeoTES in depleted oil reservoirs in Kern County, California (Partida, 2024; Umbro et al., 2025), while the second will feature a GeoTES demonstration project at Kern Front Oil Field in the same county (Cariaga, 2024c).

Co-production of geothermal energy from oil and gas reservoirs is an approach that harnesses the thermal energy present in the fluids produced during oil and gas extraction. In January 2022, DOE awarded $8.4 million to four projects as part of the Wells of Opportunity initiative. These projects—led by Geothermix, ICE Thermal Harvesting, Gradient Geothermal (formerly Transitional Energy), and University of Oklahoma—aim to repurpose inactive or idle hydrocarbon wells for geothermal energy use (GTO, 2025c).

Mineral Extraction From Geothermal Brines Could Help Address U.S. Critical Materials Competitiveness

Another emerging opportunity for geothermal is mineral extraction from geothermal brines, particularly lithium. Findings from Lawrence Berkeley National Laboratory indicate the Salton Sea lithium resource is estimated to be close to 3,400 kilotons, offering the potential to create a domestic lithium industry in the United States (Dobson et al., 2023). Technological innovations in mineral extraction technologies like direct lithium extraction continue to advance. Work to continue these advances includes GTO-funded national laboratory projects for research and development on lithium extraction in Known Geothermal Resource Areas within and beyond the Salton Sea, California, and additional projects targeting the Smackover Formation and other areas of the U.S. with mineral and geothermal potential, previously funded by GTO in collaboration with DOE's Advanced Manufacturing and Materials Office and DOE's Office of Fossil Energy (GTO, 2024c).

> The U.S. geothermal market is expanding. Recent R&D and commercial breakthroughs, accelerated investment and interest, and the demand for reliable, resilient, and efficient energy options means that the geothermal industry is poised for continued growth—for both power generation and heating and cooling.

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1. Introduction

The geothermal industry in the United States is experiencing an uptick in investment and project development activities. This is primarily due to the increasing demand for firm and flexible power and the increasing market penetration of next-generation geothermal systems.

Geothermal energy comprises (1) deep, medium- to high-temperature heat sources, for electricity and direct thermal applications, and (2) shallow, low-temperature resources for building and industrial heating and cooling applications. The global geothermal market contains an estimated 15 GWe of electricity, 38 GWth of direct-use heat, and over 78 GWth of geothermal heat pump (GHP) capacity for heating and cooling (IRENA, 2024; REN21, 2023; J. W. Lund and Toth, 2021). Project development activities have increased in recent years across multiple continents, in both the deep and shallow resource utilization sectors (REN21, 2023). Globally, new geothermal power project developments are accelerating in multiple regions, including Asia (especially in Indonesia and the Philippines), Africa, Central America, and the Caribbean (IRENA, 2024). However, the United States still currently leads the world with the largest share of installed global geothermal power capacity (23%).

The *2025 U.S. Geothermal Market Report* is a comprehensive assessment of market activities in the U.S. geothermal industry since the publication of the preceding *2021 U.S. Geothermal Power Production and District Heating Market Report* (referred to in this report as the 2021 Geothermal Market Report) (Robins et al., 2021). This latest report covers similar market segments as in the 2021 version, but with an expanded scope to include all geothermal heating and cooling applications. The report also dives into national and local market drivers that are enabling geothermal energy access, development, and deployment. The report is organized as follows:

SECTION 2

Section 2 presents the methodology for classifying resources and technologies for both geothermal electricity and geothermal heating and cooling applications.

SECTION 3

Section 3 discusses geothermal power. This includes updates to the geothermal electricity market and an assessment of the impacts of developmental activities on installed capacity and cost, including both conventional hydrothermal systems and next-generation (i.e., enhanced geothermal and closed-loop geothermal) systems.

SECTION 4

Section 4 is dedicated to geothermal heating and cooling. This section presents first-of-its-kind data and analysis on GHP installations in residential and commercial buildings in the United States. The section also delineates the component contributors to GHP cost variability and describes some case studies on market drivers. Section 4 also provides updates on direct use of geothermal heat for multiple purposes, including district heating, space heating, greenhouses, resorts and pools, and aquaculture. Additionally, this section presents insights into direct applications in the industrial sector.

SECTION 5

Section 5 discusses market drivers. This section presents a summary of compiled data on federal, state, and utility service territory market drivers for geothermal electricity, GHPs, and direct use. These market drivers include incentives, regulatory policies, and rebates that support the deployment of geothermal installations in their respective jurisdictions.

SECTION 6

Section 6 provides updates on emerging geothermal technologies and applications. These include superhot geothermal, mineral extraction, reservoir thermal energy storage, and co-production. Section 6 discusses progress in research, development, and demonstration of these technologies and their anticipated impacts on the U.S. geothermal market.

SECTION 7

Section 7 concludes the report by giving a high-level summary of the current state of the U.S. geothermal market. This section also briefly discusses potential future updates to the content and data compiled in this report.

2. Definitions and Data Sources

This report represents a large effort to assess the geothermal market in the United States. There are many different industry players, and terminology and data sources can vary. This section clarifies the sources and approaches used in the report when analyzing data, and describes the definitions used for resources and technologies.

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First, a few broad definitions:

- **Geothermal power generation** refers to a typically large, utility-scale power plant that uses geothermal resources (e.g., hydrothermal and petrothermal/hot dry rock) to generate electricity.
- **Geothermal heating and cooling** refers to building and industrial heating and cooling applications—e.g., GHPs, direct use—for either individual buildings or multiple buildings, known as districts.

As discussed in the introduction, this report is divided into an analysis of the U.S. geothermal market as it relates to electricity production, and then heating and cooling. Section 2.1 provides definitions and describes the approach to collecting and analyzing data on geothermal power production, then Section 2.2 defines power capacity types, resource types, and phases of resource development.

2.1 Geothermal Power Production

2.1.1 Power Production Data Sources

For power production, this report builds upon a database originally developed by the Geothermal Energy Association[5] and updated in 2019 by Geothermal Rising and the National Laboratory of the Rockies (NLR) for the 2021 Geothermal Market Report. The database has been updated with power production data procured by Geothermal Rising and NLR through June 2024. To gather this information, Geothermal Rising distributed a questionnaire (Appendix A.1) in December 2023 to active geothermal operators and developers in the United States. Geothermal Rising designed the questionnaire to collect data on current power production capacities and projects under development, and subsequently integrated the responses obtained into the existing database as documented in Appendix A. It is important to note that Calpine, the largest geothermal operator in California, opted not to participate in the survey conducted by Geothermal Rising. Consequently, this report incorporates a mix of data from the 2021 Geothermal Market Report and the U.S. Energy Information Administration (EIA) Annual Electric Power Industry Report Form EIA-860 to represent Calpine's nameplate capacity data. NLR incorporated plant data for other non-responsive operators from Form EIA-860.

From 2010 to 2016, the Geothermal Energy Association published an annual *U.S. Geothermal Power Production and Development Report*. To enhance the accuracy and usefulness of the data presented in these reports, the Geothermal Energy Association introduced a reporting system called "New Geothermal Reporting Terms and Definitions" (Geothermal Energy Association, 2010). This system provided guidelines for project developers to report geothermal project development information to the Geothermal Energy Association between 2010 and 2016. Aside from introducing closed-loop geothermal (CLG) (i.e., advanced geothermal systems) as a new geothermal technology application, Geothermal Rising maintained consistent reporting terms in its 2023 questionnaire.

[5] The Geothermal Energy Association merged with Geothermal Rising in 2018 and no longer exists as a separate entity.

2.1.2 Geothermal Power Capacity Types

Geothermal power plant developers use the following definitions to report power plant capacity:

- **Installed Nameplate Capacity:** The maximum rated output of a generator, prime mover, or other electric power production equipment under specific conditions set by the manufacturer. This capacity is typically measured in megawatt-electrical (MWe) and is usually indicated on a nameplate affixed to the generator.
- **Summer Capacity:** The maximum output, typically measured in MWe, that generating equipment can provide to the system load during peak summer demand (i.e., June 1 through September 30). This output accounts for a reduction in capacity due to electricity consumption for station services or auxiliaries, representing the plant's net capacity on a summer day.
- **Winter Capacity:** The maximum output, typically measured in MWe, that generating equipment can provide to the system load during peak winter demand (i.e., December 1 through February 28). As with summer capacity, this output accounts for a reduction in capacity due to electricity consumption for station services or auxiliaries, representing the plant's net capacity on a winter day.

Note that winter capacity is usually higher than summer capacity due to the lower ambient temperatures. This is because of the larger temperature difference between the cooling fluid (e.g., air, water) and working fluid, which results in a higher plant efficiency.

2.1.3 Geothermal Power Resource Types

Based on Geothermal Rising's guidelines for reporting resource development progress, the analysis team used the following definitions to classify projects in the December 2023 questionnaire sent to geothermal project developers and operators:

Conventional Hydrothermal (CH)

- **Unproduced Resource:** The development of a resource in which the geothermal reservoir has naturally sufficient temperature and flow capacity to generate electricity, but the reservoir has not yet been developed enough to support the operation of geothermal power plant(s). This type of project is labeled "CH Unproduced" in this report.
- **Produced Resource:** The development of a resource in which the geothermal reservoir has naturally sufficient temperature and flow capacity to generate electricity, and the reservoir has previously been developed enough to support the operation of geothermal power plant(s). This type of project is labeled "CH Produced" in this report.
- **Expansion:** The expansion of an existing geothermal power plant (e.g., well drilling and stimulation, geofluid reinjection, upgraded power plant equipment) to increase the power output. This type of project is labeled "CH Expansion" in this report.

Other Geothermal Resource Types

- **Geothermal Co-Production:** The utilization of fluids produced from oil and/or gas field development to generate geothermal power. This type of project is labeled "Co-Production" in this report.
- **Enhanced Geothermal System (EGS):** The development of a geothermal system in which a human-made rock fracture network connects multiple wells and enables subsurface fluid circulation and heat extraction. This type of project is labeled "EGS" in this report.
- **Closed-Loop Geothermal (CLG; i.e., Advanced Geothermal System):** The development or expansion of a geothermal system to enable the circulation of a working fluid in a subsurface wellbore without direct contact with the reservoir to bring heat to the surface for power generation. These include closed-loop and other forms of downhole heat exchangers. This type of project is labeled "CLG" in this report.

2.1.4 Geothermal Plant Types

The various geothermal plant types in operation are defined as follows:

- **Dry steam power plant:** A geothermal power plant that directly utilizes the thermal energy from a dry steam geothermal resource to drive a steam turbine.
- **Flash power plant:** A geothermal power plant that directly converts geothermal fluids into steam that drives a turbine. The plant could be single flash, dual (or double) flash, or triple flash plants, with one, two, and three flashing stages, respectively.
- **Binary cycle power plant:** A geothermal power plant in which geothermal fluids are used to heat a secondary working fluid that, in turn, drives a turbine. The most common binary cycle in the geothermal industry is the organic Rankine cycle (ORC). These plants can operate at lower temperatures than flash power plants. These closed cycles avoid the release of naturally occurring gas within the geothermal fluids into the atmosphere.
- **Backpressure power plant:** This is a dry steam or flash power plant that uses a backpressure turbine instead of a typical condensing steam turbine to generate electricity. The spent steam from the turbine exhaust is vented directly into the atmosphere.

2.1.5 Project Development Timeline

In addition to defining projects according to the above definitions, in its 2023 questionnaire Geothermal Rising requested developers to identify each project's current stage in the development timeline using a four-phase system (or classify them as "Prospect" for resources not yet meeting the criteria for Phase I). This system reflects the extent and nature of the work completed on a given geothermal project. The phases of project development are defined as follows:

- **Prospect (i.e., Early Resource Identification)** includes literature review and analysis of geological, geophysical, and geochemical surveys.
- **Phase I: Resource Procurement and Identification** includes identification of potential high-temperature zones, assessment of reservoir properties, power transmission analysis, land or lease acquisition, and processing permits for exploration drilling.
- **Phase II: Resource Exploration and Confirmation** includes drilling of temperature gradient, slim, or full-size discovery wells, application to interconnection and transmission development, and processing permits for production well drilling.
- **Phase III: Permitting and Initial Development** includes reservoir characterization, drilling of one full-size production and/or injection well, completing a transmission feasibility study, conducting system impact study, processing a power plant permit, power purchase agreement (PPA) secured or in negotiation, and financing allocated for a portion of the project construction.
- **Phase IV: Resource Production and Power Plant Construction** includes power plant construction activities, production and injection well drilling, completing transmission system service request studies, signing a large generator interconnection agreement, acquiring power plant permits, signing engineering, procurement, and construction contracts, and securing a PPA.

Within each phase, project development activities are classified under three distinct categories, each containing specific subcriteria. These activity categories include resource development, transmission development, and external to resource development (e.g., land access acquisition; permitting; signing PPAs; engineering, procurement and construction contracts; and securing partial project financing). For a project to qualify for a specific development phase, it must meet a combination of subcriteria unique to that phase. If none of these criteria are fulfilled, the project is classified as a Prospect.

2.2 Geothermal Heating and Cooling

This section includes definitions and data sources for building and industrial heating and cooling applications—GHPs and district heating/cooling.

2.2.1 Geothermal Heat Pump Definitions and Data Sources

GHPs are efficient energy systems that utilize the stable temperature of the earth to provide heating and cooling for residential, commercial, and industrial buildings. Current data on GHP installations are limited, so NLR developed a first-of-its-kind database of GHP installations nationwide. This effort to characterize the state of GHPs expands on the work of the 2021 Geothermal Market Report (Robins et al., 2021), which primarily focused on direct-use geothermal systems and did not include GHPs. The newly compiled NLR database contains 70,470 records, largely sourced from state well permits and supplemented by small-scale studies.

NLR also collaborated with the International Ground Source Heat Pump Association (IGSHPA) to standardize GHP terminology, which has historically been inconsistent. To address this, IGSHPA distributed a survey (Appendix C) to its members, collecting insights on the most frequently used terms in the industry. Based on the survey results, this report uses the following terminology:

- **Geothermal heat pump:** A device utilizing the ground as a heat source or sink for heating and cooling, typically serving single-family buildings.
- **Closed-loop GHP system:** A continuous, sealed, underground, or submerged heat exchanger through which a heat transfer fluid passes to and returns from a heat pump.
- **Open-loop GHP system:** A heat pump system designed to use groundwater or surface water (e.g., ponds, lakes, and rivers). Water is pumped to the ground surface and circulated through the heat pump.

2.2.2 Geothermal District Heating and Cooling Definitions and Data Sources

Geothermal district heating refers to using geothermal energy to heat buildings via a distribution network. The term comprises multiple system types, which often overlap.

Geothermal direct use (GDU) refers to the "direct use" (i.e., not converting the energy into electricity or using heat pumps) of geothermal heat in residential, commercial, and industrial settings. In residential and commercial building settings, the scale of application could comprise both single building and district heating.

Following are geothermal district heating and cooling system type definitions, followed by a short discussion of the differences:

- **Geothermal district heating and cooling:** A system that generates and distributes heated and chilled fluids through a network of insulated pipes or GHP systems to provide hot water, heating, and/or cooling services to standalone or networked buildings.
  - **1G, 2G, and 3G district system:** These are earlier and less efficient "generations" of district heating, ranging from direct use of steam in the 1800s (1G), to the use of pressurized hot water (2G), to the use of lower-temperature pressurized hot water (3G).
  - **4G geothermal district systems:** Fourth-generation (4G) systems produce hot and cold fluid from a central plant to a group of buildings. One type of 4G system is geothermal direct-use district heating where hot subsurface fluid is used directly to heat buildings in a district.
  - **5G geothermal district system:** Fifth-generation (5G) systems supply near-ambient fluid to connected buildings to provide heating or cooling via decentralized GHPs.
  - **Geothermal-based Thermal Energy Network (TEN):** Geothermal district heating and cooling systems with decentralized GHPs connected to a shared ambient-temperature distribution loop.

To elaborate, 5G systems are characterized by decentralized GHPs or water-source heat pumps[6] and a pipeline network configuration with a bidirectional energy distribution loop. The main distribution loop could be a single ambient temperature loop or a two-pipe (heating and cooling) loop (Magavi et al., 2024; Simpson et al., 2024). Apart from geothermal boreholes, 5G systems can also utilize solar thermal and waste heat (e.g., from data centers or wastewater treatment plants).

TENs that primarily utilize shallow geothermal resources (e.g., shallow bedrock and aquifers) as a source and/or sink through boreholes and distribute this energy to decentralized GHPs in multiple buildings have been called several names, including geothermal networks, networked geothermal, and geothermal energy networks. There is an ongoing effort to streamline terminologies and taxonomies of geothermal-based TENs (Magavi et al., 2024). Therefore this report will refer to GHP-based 5G district heating and cooling systems with single or multiple loops simply as TENs.

Turning to data sources, the data used to analyze GDU systems in this report are sourced from the NLR Geothermal Direct-Use database (Snyder et al., 2017) and are supplemented by information from news articles, publications, and direct data collation from interviews and email correspondences with project owners and operators conducted in 2020, 2023, and 2024.[7] The NLR database, developed in 2016, originally evolved from records maintained by the Oregon Institute of Technology Geo-Heat Center dating back to 1975. It includes details such as application type, installed capacity, well flow rates, and production temperatures, though many entries are incomplete. Since 2017, NLR has worked to verify and update this information. However, the lack of standardized reporting requirements in the United States presents challenges in keeping the database up-to-date and identifying all active GDU sites.

Photo by Eric Larson, Flash Point SLC

[6] A water-source heat pump uses water as a heat source or sink for heating and cooling buildings.
[7] The updated geothermal direct use database is hosted on the Geothermal Data Repository and can be accessed at https://gdr.openei.org/submissions/1803

3. Geothermal Power Market Update

The U.S. geothermal power production market has experienced moderate net capacity growth since 2020. This growth is matched by a slight increase in the number of operating geothermal plants and the retirement of older generating plants that have become largely uneconomical. The addition of 26 PPAs (see Section 3.2.5) since the 2021 Geothermal Market Report, changes in policy, successful field demonstration and commercialization of next-generation geothermal system designs, and interest in geothermal as a firm and dispatchable energy source indicate that the sector is primed for growth in the coming years.

A primary driver for the acceleration of geothermal power projects since 2021 has been a procurement order by the California Public Utilities Commission (CPUC). In June 2021, the CPUC mandated load-serving entities within its jurisdiction to procure at least 11.5 gigawatt-electric (GWe) of new renewable energy resources and battery energy storage by 2026, including 1 GWe of firm power.[8] These mid-term reliability obligations have spurred signings of at least 616 MWe[9] (as of June 2025) in PPAs between geothermal developers and load-serving entities in California, including utilities, energy service providers, and community choice aggregators.

Additionally, the increased interest in geothermal power has been driven in part by the surge in data center demand for firm power (Barth et al., 2025); several geothermal PPAs (Cariaga, 2024d) and other offtake agreements (Cariaga, 2024a; Business Wire, 2025b) involve large technology companies such as Google and Meta.

Geothermal power market trends in this section rely on industry survey responses, and some developers chose not to share data publicly.

3.1 Geothermal Power Generation

3.1.1 Geothermal Resource Assessment and Mapping Updates

Improving understanding of subsurface temperature variations and the characteristic geologic features throughout the United States is vital to the continued exploration and development of geothermal power projects. Geothermal resources are generally characterized as conventional hydrothermal or petrothermal (also known as hot dry rock) systems, where the latter are candidates for EGS and CLG development due to the lack of natural permeability and suitable fluid flow. Over the past several decades, numerous efforts modeled surface heat flow and temperature-at-depth to estimate geothermal resource potential, including Blackwell et al (2006, 2011), Boyd (2019), Lachenbruch and Sass (1977), Massachusetts Institute of Technology (2006), Mullane et al. (2016), and Morgan and Gosnold (1989). Southern Methodist University developed a nationwide model for depths of 3.5–10 km (Blackwell et al., 2011), which researchers then extrapolated to capture shallower depths (Mullane et al., 2016). Other more recent models have been developed by the U.S. Geological Survey for the Great Basin (Burns et al., 2024) and the Stanford Geothermal Program for the contiguous United States (Aljubran and Horne, 2024c), which notably uses more data sources in conjunction with a physics-informed neural network. Figure 1 shows temperature-at-depth layers of the Stanford model, overlayed by isotherms of the Southern Methodist University model.

Using these models, Stanford investigated geothermal power potential across the contiguous United States. Aljubran and Horne (2025) estimated a total of 3,632 and 17,789 MWe of available identified and undiscovered hydrothermal resources, respectively.[10] Aljubran and Horne also modeled EGS life cycle techno-economics and estimated a total EGS capacity potential of 245,032 GWe across depths of 1 to 7 km (Aljubran and Horne, 2024b). The Stanford EGS resource estimates do not include economic constraints.

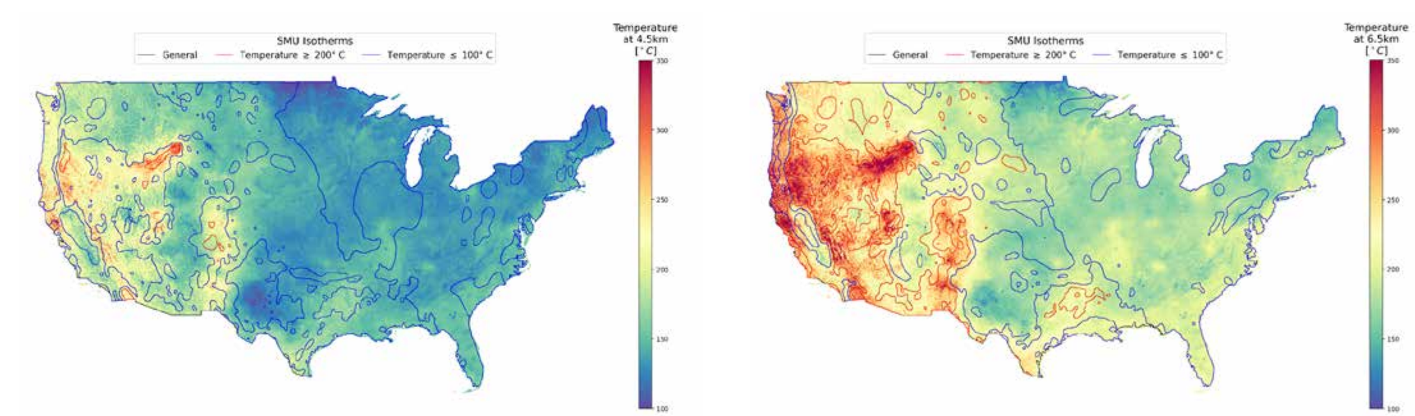

Figure 1. Temperature-at-depth model predictions by the Stanford model, overlain by isotherms of the Southern Methodist University model, at depths of 4.5 km (left) and 6.5 km (right). *Maps from Aljubran and Horne (2024b); SMU = Southern Methodist University*

[8] Firm power refers to sources that are "always on," like geothermal, and can provide power whenever they are needed. This is in contrast to intermittent resources, like wind or solar, which are dependent on weather or time of day.

[9] Sixteen PPAs totaling 888 MWe, have been signed in California since the 2021 procurement order. NLR researchers found association between ten of these PPAs since the 2021 procurement order, resulting in the promise of at least 616 MWe.

[10] "Identified" hydrothermal resources are known geothermal resource areas where heat, water, and permeability are available. "Undiscovered" hydrothermal resources are potential locations where heat, water, and permeability may exist, estimated via GIS-based statistical modeling or other data-driven modeling techniques.

Separately, NLR researchers used the Renewable Energy Potential (reV) model to estimate the technical potential and supply curves for both hydrothermal and EGS resources across the conterminous United States, while considering geospatial constraints such as restricted land use as well as environmental and social factors (Pinchuk et al., 2023; Trainor-Guitton et al., 2024). The reV model calls upon NLR's System Advisor Model (SAM) and uses Geothermal Electricity Technology Evaluation Model (GETEM) parameter assumptions for site-specific geothermal performance and financial analysis (Mines, 2016). Using the reV model, the *EGS resource capacity* between 1- and 7-km depth across the conterminous United States is estimated to be between 26,556 GWe and 57,021 GWe based on the Blackwell et al. (2006, 2011) and the Aljubran and Horne (2024a) temperature-at-depth maps, respectively (Menon et al., 2025). Blackwell et al. (2006, 2011) provides the Southern Methodist University temperature model while Aljubran and Horne (2024c) provides the Stanford Temperature Model. Figure 2 shows the reV-generated geospatial distribution of EGS resource potential at depths of 4 km, 5 km, and 6 km for each of these models (Menon et al., 2025). The resource potential using the Southern Methodist University model is estimated as 2,693 GWe, 5,190 GWe, and 8,803 GWe at 4 km, 5 km, and 6 km, respectively, while the Stanford Temperature Model estimates 4,791 GWe, 10,580 GWe, and 16,203 GWe across the same range of depths. The Stanford Temperature Model generally estimated higher resource capacities (due to higher estimated temperatures at depth) compared to the Southern Methodist University Model. The differences between the model estimates are due to variations in the underlying datasets, modeling approaches, and intrinsic assumptions (Aljubran and Horne, 2024b).

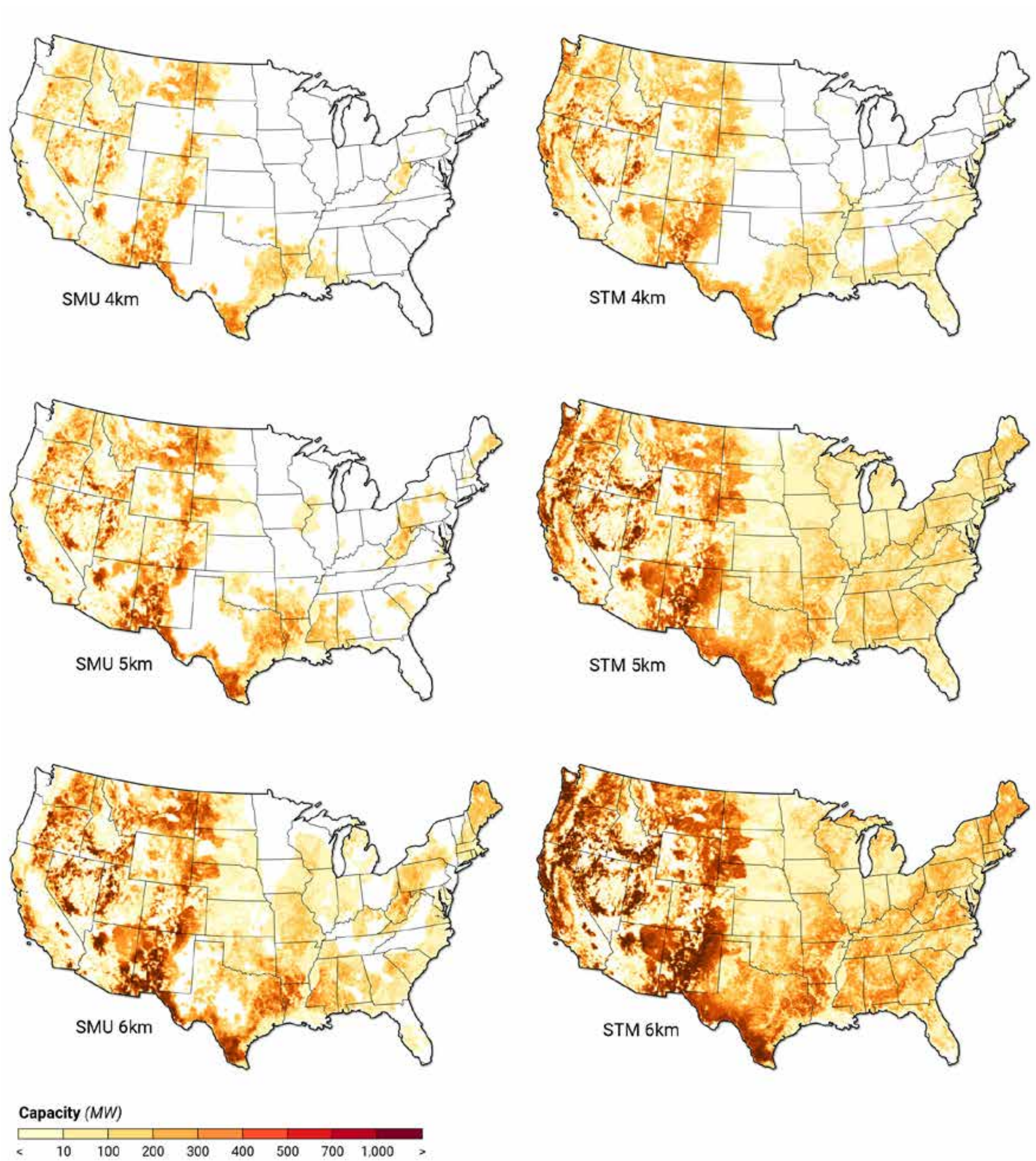

Figure 2. reV-based estimation of power output potential for EGS resources at 4-km, 5-km, and 6-km depths using Southern Methodist University and Stanford temperature models. *All report figures by NLR, unless noted otherwise. SMU = Southern Methodist University. STM = Stanford Temperature Model.*

3.1.2 General Market Activity Updates

As mentioned in Section 2, Geothermal Rising issued a survey (Appendix A) in December 2023 to U.S. geothermal power plant operators and developers to compile up-to-date information on current and developing installations. These data, along with data from the EIA (EIA, 2024a, 2024d) (updated as of June 2024) and the Bureau of Land Management (BLM), report that nine new plants have come online between June 2021 and June 2024, adding 246 MWe of nameplate capacity (Table 1). In the same period, six plants were retired or have been classified as non-operational, subtracting 82 MWe of nameplate capacity (Table 2). In addition, nine plants have reported changes in capacity due to expansion projects or losses in efficiency; these changes net 132 GWe of additional capacity (Figure 3). Based on these updated data, as of June 2024, geothermal installed capacity in the United States has increased slightly since the 2021 Geothermal Market Report. As shown in Figure 4, the current nameplate capacity of 3,969 MWe from 99 power plants displays growth from the 3,673 MWe from 93 power plants reported in 2020.

TABLE 1. New Plants Brought Online Between 2020 and June 2024
Based on the Geothermal Rising survey (Appendix A) along with data from the EIA and BLM.

Name	Operator	State	Plant Type	Operational Year	MWe
CD4 - Mammoth Lakes (ORNI 50)	Ormat	CA	Binary	2022	44.4
Heber II OEC 1 and 2	Ormat	CA	Binary	2022	42.5
HXC1	Gradient	NV	Co-Production	2022	0.075
McGinness Hills 3A (ORNI 41)	Ormat	NV	Binary	2021	24.8
North Valley (ORNI 36)	Ormat	CA	Binary	2023	31.5
Ormesa III (Ormesa Complex)	Ormat	CA	Binary	2020	24.0
Star Peak Geothermal Plant	Open Mountain Energy	NV	Binary	2022	21.9
Steamboat Hills (Repower)*	Ormat	NV	Binary	2020	31.6
Tungsten Mountain 2	Ormat	NV	Binary	2022	25.5
				Total MW	**246.3**

TABLE 2. Plants Retired Between 2020 and June 2024
Based on the Geothermal Rising survey (Appendix A) along with data from the EIA and BLM.

Name	Operator	State	Plant Type	Status	MWe
GEM II (Ormesa Complex)	Ormat	CA	Double Flash	Inactive	21.6
GEM III (Ormesa Complex)	Ormat	CA	Double Flash	Retired	21.6
GEM Bottoming Unit (Ormesa Complex)	Ormat	CA	Binary	Inactive	8.0
Soda Lake 2	Cyrq	NV	Binary	Retired	9.0
Steamboat Hills Bottoming	Ormat	NV	Single Flash	Retired	5.5
Steamboat Hills STG	Ormat	NV	Binary	Retired	16.3
				Total MW	**82.0**

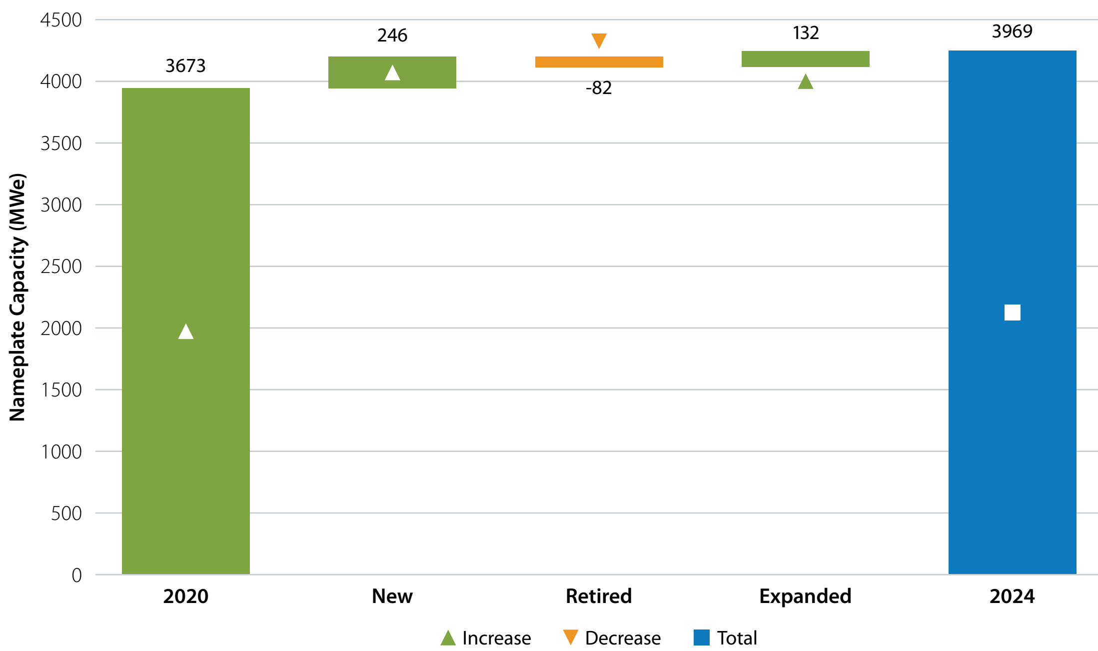

Figure 3. U.S. geothermal nameplate capacity growth since the 2021 Geothermal Market Report, as of June 2024

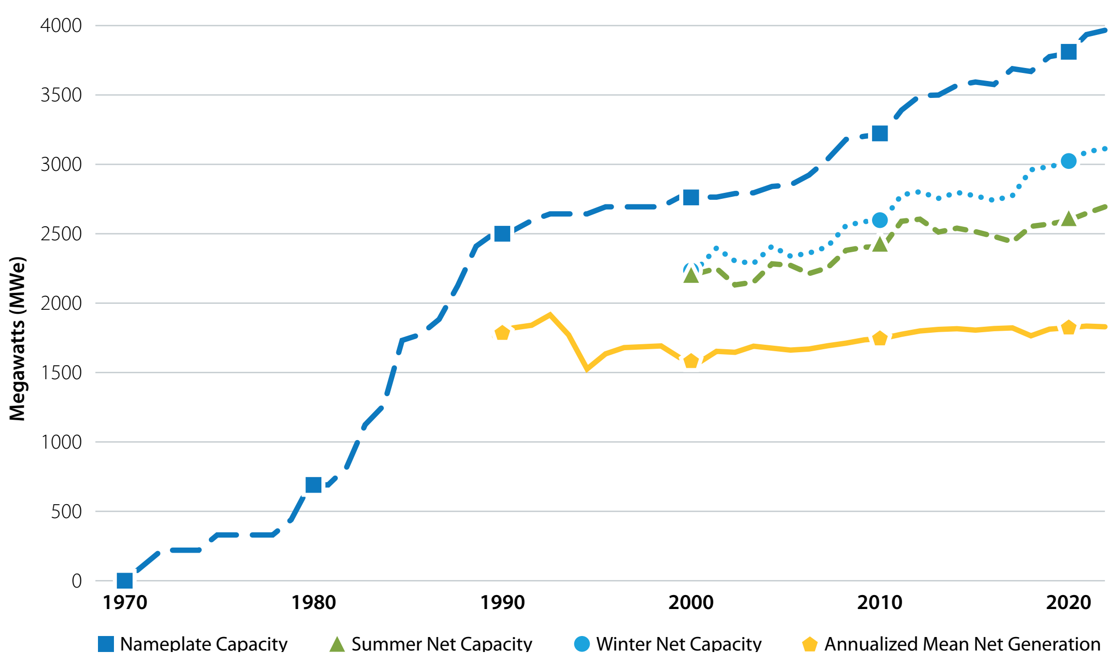

Figure 4. U.S. industry geothermal nameplate and net capacity, as well as annualized mean net generation. *Data from the Geothermal Rising 2023 industry survey and the EIA (2024). The EIA data cover historical nameplate capacity, summer net capacity, winter net capacity, and annualized mean net generation up to 2023. Data include generators that are currently operating, out of service, and on standby.*

The seasonal net capacity has increased over the years, with summer net capacity rising from 2,555 MWe in 2019 to 2,693 MWe in 2023, and winter net capacity (see Section 2.1.2 for definitions) growing from 2,963 MWe to 3,115 MWe (EIA, 2024a). Despite these gains, the annualized mean net generation (i.e., the ratio of total annual generation in megawatt-hours to total hours in a year, or utility scale generation in Figure 4) has only seen a modest increase, from 1,766 MWe in 2019 to 1,831 MWe in 2023. This limited growth is primarily due to factors such as efficiency losses from resource degradation and aging infrastructure, which have caused the output from older plants to decline, effectively offsetting the gains from newer plants.

3.1.3 Age of Geothermal Power Plants

Geothermal plants have a typical operational lifespan of 30–50 years (Basosi et al., 2020; Enel, 2024), depending largely on the geothermal resource, technology, and maintenance of the system, making the age of the current fleet a key factor in planning for reinvestment or retirement. In 2020, 44% of plants were more than 30 years old, and these plants

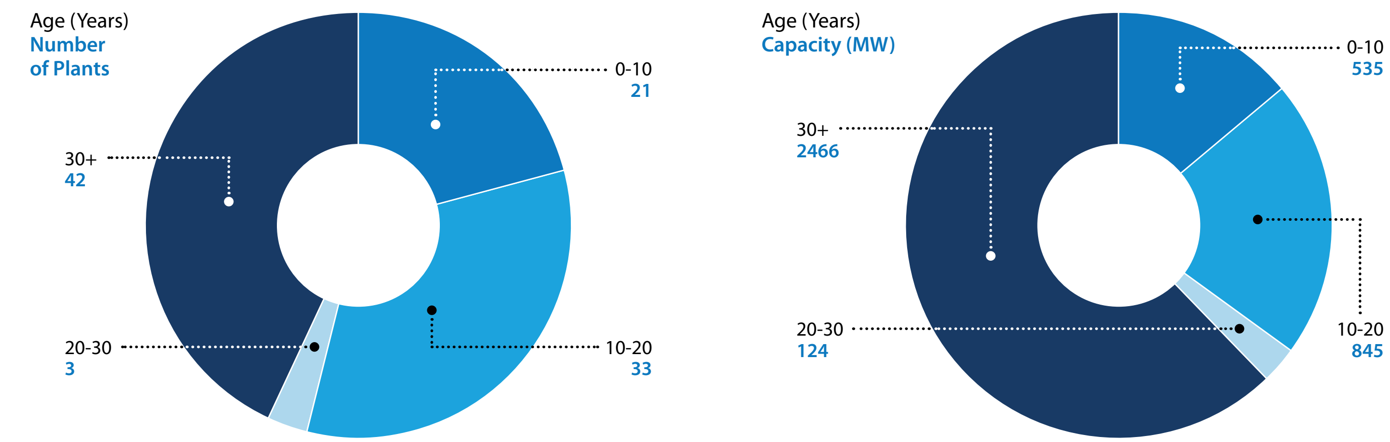

Figure 5. Age of U.S. geothermal plants by percentage of total number (left) and capacity (right)

accounted for 64% of total nameplate capacity (Robins et al., 2021). With 246 MWe of capacity added since 2020, these numbers have shifted slightly, as shown in Figure 5. As of mid-2024, 43% of geothermal power plants were more than 30 years old, representing 62% of total nameplate capacity.

3.1.4 Plant Technology Market Share

Figure 6 illustrates that dry steam and flash technologies have traditionally been the backbone of U.S. geothermal power production. However, nearly all capacity additions from 2020 to 2024 (53 out of 61 plants) were binary plants, matching the historical global shift toward binary technologies as seen in Akar et al. (2017). Although flash plants generally achieve higher efficiencies at high temperatures (Zarrouk and Moon, 2014), they come with operational challenges like scaling, corrosion, non-condensable gas handling, and water replacement costs. In contrast, binary plants are more flexible and can

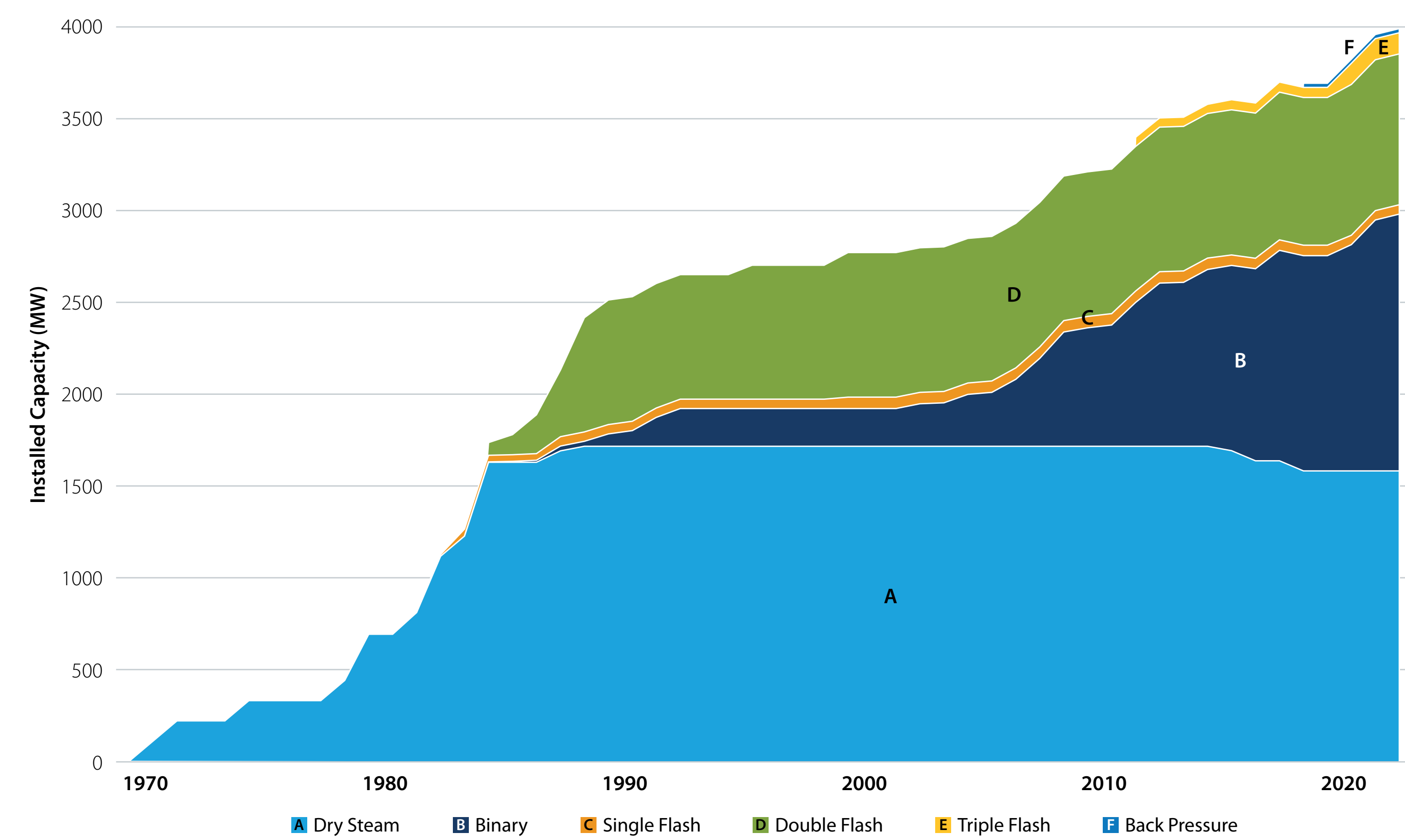

Figure 6. U.S. geothermal capacity by plant technology

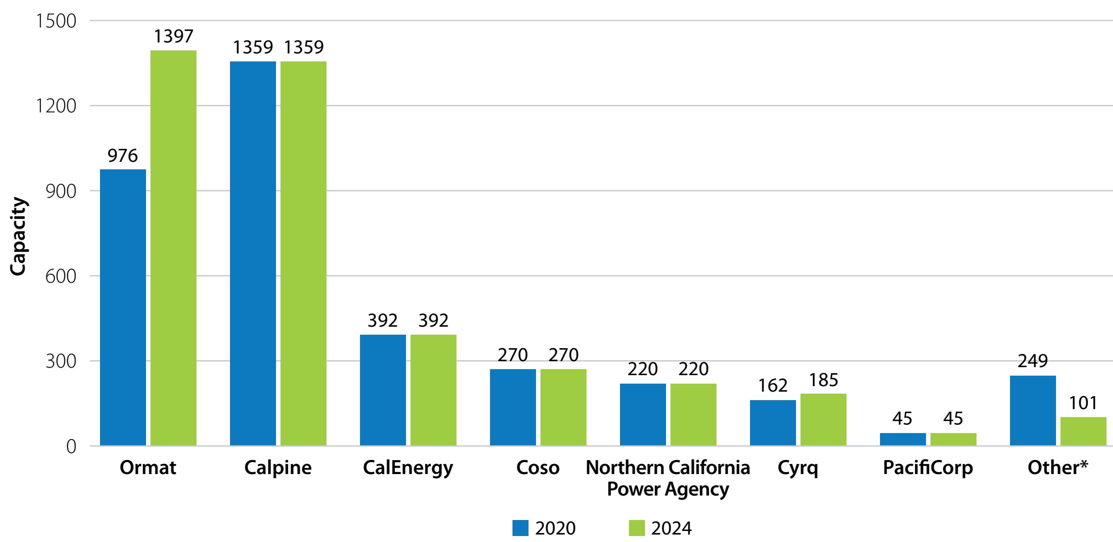

Figure 7. U.S. geothermal nameplate capacity by operator

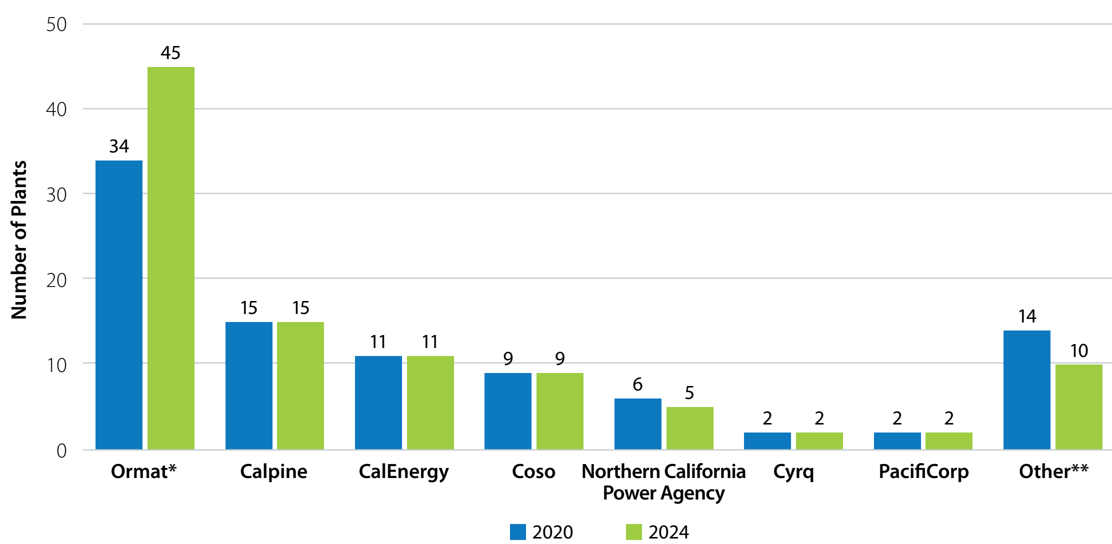

Figure 8. U.S. geothermal power plant count by operator

* Terra Gen and Enel were both acquired by Ormat in 2021 and 2024, respectively.

** In 2020, "Other" consists of Terra Gen, Enel, Energy Source, Open Mountain Energy, Surprise Valley Electric Corp, OIT, and Chena Hot Springs. In 2024, this list excludes Terra Gen and Enel and includes Gradient and Zanskar. In May 2025, Ormat acquired the Blue Mountain Geothermal Power Plant from Cyrq. We have not included the additional capacity in this chart since this occurred in 2025.

accommodate a variety of working fluids, allowing for the use of lower-temperature (less than ~200°C) resources.

3.1.5 Capacity Updates by Operator Since 2020

Figure 7 and Figure 8 reveal that the leading operators in the U.S. geothermal power industry have remained largely consistent since the 2021 Geothermal Market Report, with Calpine and Ormat together providing 71% of all geothermal capacity and operating 62% of all U.S. geothermal plants. Despite accounting for a large portion of the market share, these two companies operate under very different business models. Calpine has an installed capacity of 1,359 MWe from just 15 power plants, averaging 91 MWe per plant. In contrast, Ormat operates 46 plants, with a total capacity of 1,446 MWe, which averages 32 MWe per plant. This divergence in electricity output per plant is primarily due to the type of resources each company exploits. Calpine relies exclusively on dry steam plants at The Geysers, the largest single source of geothermal power in the world and the only dry steam field currently in production in the United States (GTO, 2025a). In contrast, the majority of Ormat's power generation projects are binary plants (see Appendix B) utilizing geothermal energy from lower-enthalpy[11] resources, necessitating a larger number of plants to produce a comparable amount of electricity.

3.1.6 Production by State

The relationship between resource temperature and power generation is also evident in Figure 9. California and Nevada, which host most of the highest-temperature geothermal resources in the United States, account for the majority (94%) of geothermal power production. California, which has high-temperature resources at The Geysers, Salton Sea, and Coso, has an installed nameplate capacity of 2,868 MWe, representing 72% of the total U.S. geothermal power production. Additionally, California is home to 53 of the 99 geothermal power plants in the country. Nevada, with significant identified/undiscovered hydrothermal and next-generation resource potential, has 32 power plants with an installed nameplate capacity of 892 MWe.

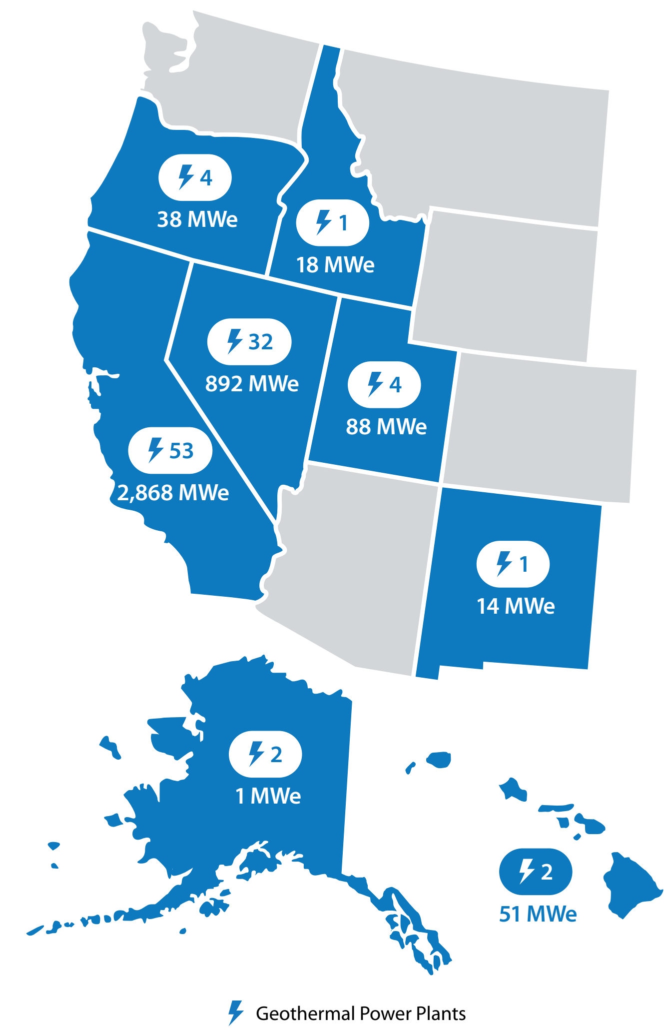

Figure 9. Distribution and installed nameplate capacity of geothermal plants in the United States as of June 2024 (EIA, 2024a, 2024d). *In the power plant totals for each state, a single plant is described by the year installed (Appendix B). Some plants (e.g., McGinness Hills) have been expanded in subsequent years after the first unit was installed. These are treated as separate plants as shown in Appendix B.*

3.2 Developing Commercial Projects

Based on the data collected in the Geothermal Rising survey and further investigation performed by NLR, there were 54 developing geothermal projects in the United States in 2024. This is four fewer than the number of developing projects (58) reported in the 2021 Market Report. However, on the basis of projects with active operators that are still in business today, there were zero net project additions between 2020 and 2024. This comparison is solely based on project count and not on the proposed total capacity from these projects. Developing projects are defined according to the four phases of development (and prospect) system detailed in Section 2.1.4, capturing projects in their earliest phases of literature review and resource identification through the later phases of exploratory drilling, permitting, and power plant construction.

Data in this section may be incomplete given the dynamic nature of developing projects, limited participation in the industry survey, and limitations of public data NLR accessed to augment the survey. While these factors affect the ability to fully assess the number of developing projects, data still indicate that geothermal project development is progressing.

3.2.1 Project Activity by Operator

Ormat continues to have the highest number of developing commercial projects (26 of the 54 total projects reported) of any operator in the United States (Figure 10). Several of the

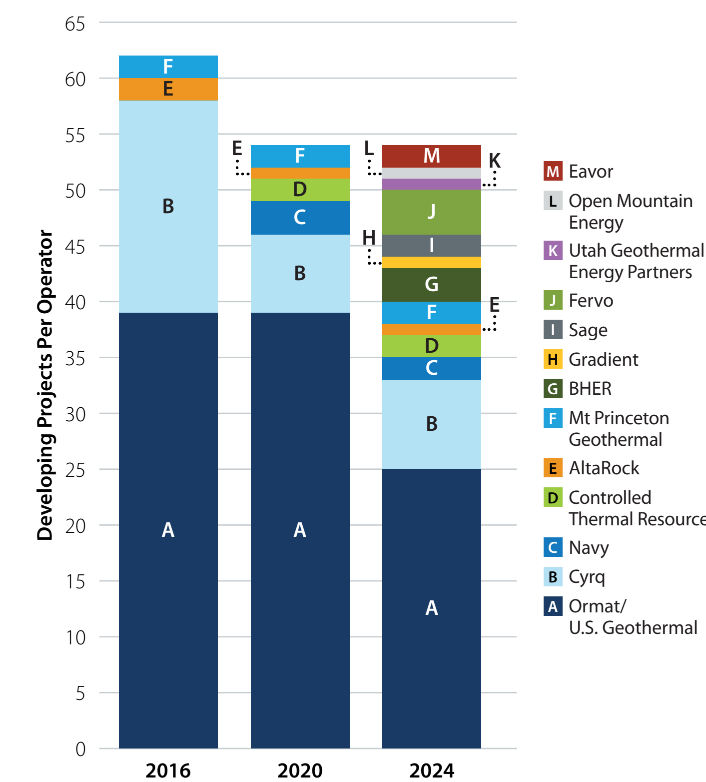

Figure 10. U.S. geothermal developing projects by operator as reported in the 2023 industry survey with additions confirmed by NLR analysts, excluding operators that are no longer active. *This chart includes data that were not reported in the 2023 industry survey but were confirmed as being in development through investigation by NLR analysts.*

[11] Enthalpy refers to the internal energy, pressure, and volume of a system.

previously reported companies have gone out of business or ceased further development, but there are a number of new additions. For example, Fervo Energy, a next-generation geothermal power developer, has four EGS projects in development, including one in Nevada that has started to provide electricity to Google data centers (Norbeck and Latimer, 2023; Terrell, 2023) (see Section 3.7 for more details on the potential role of geothermal regarding data centers).

3.2.2 Project Activity by State

Figure 11 shows that developing projects continue to be concentrated in the western United States. Whereas both Nevada and California have vast geothermal resources, geothermal development in Nevada is typically faster than California because authority for geothermal projects in Nevada is shared by federal and state agencies which allows for a more streamlined permitting process (Levine et al., 2022). Conversely, California project development timelines may be impacted by federal, state, and local regulatory permitting and environmental review requirements as well as coordination efforts between federal, state, and local agencies (Levine et al., 2022). Examples in other locations include Sage Geosystems notably developing the first EGS project in Texas (Elbein, 2024), Cyrq Energy activity in Alaska's Kenai Peninsula, with four CH projects in early development, and Fervo Energy's activity in Utah.

3.2.3 Project Activity by Resource Type

Geothermal Rising asked survey participants to provide their developing project resource type (see Section 2.1.3), as seen in Figure 12. The majority of reported developing projects, 35 of 54, are classified as CH Unproduced, meaning they are targeting previously undeveloped hydrothermal fields. Undeveloped fields inherently have higher risks associated with them, as there are scarce historical data to ensure reservoir properties like temperature and heat flow will meet production requirements. The EGS industry is expected to see substantial growth in coming years as the resource potential is demonstrated, hinging on the continued success of the six developing projects and technological advancements such as those seen at the Frontier Observatory for Research in Geothermal Energy (FORGE) in Utah (see Section 3.5). From the data supplied by the survey respondents, the planned power capacity per project for the EGS projects was more than three times the planned power capacity per project of the hydrothermal projects. Therefore, a small decrease in the number of planned hydrothermal projects is compensated for by a corresponding increase in capacity from EGS projects.

3.2.4 Drilling Activities and Wells Spudded Since 2020

Based on data collated from state regulators, 87 new geothermal wells for power generation have been either

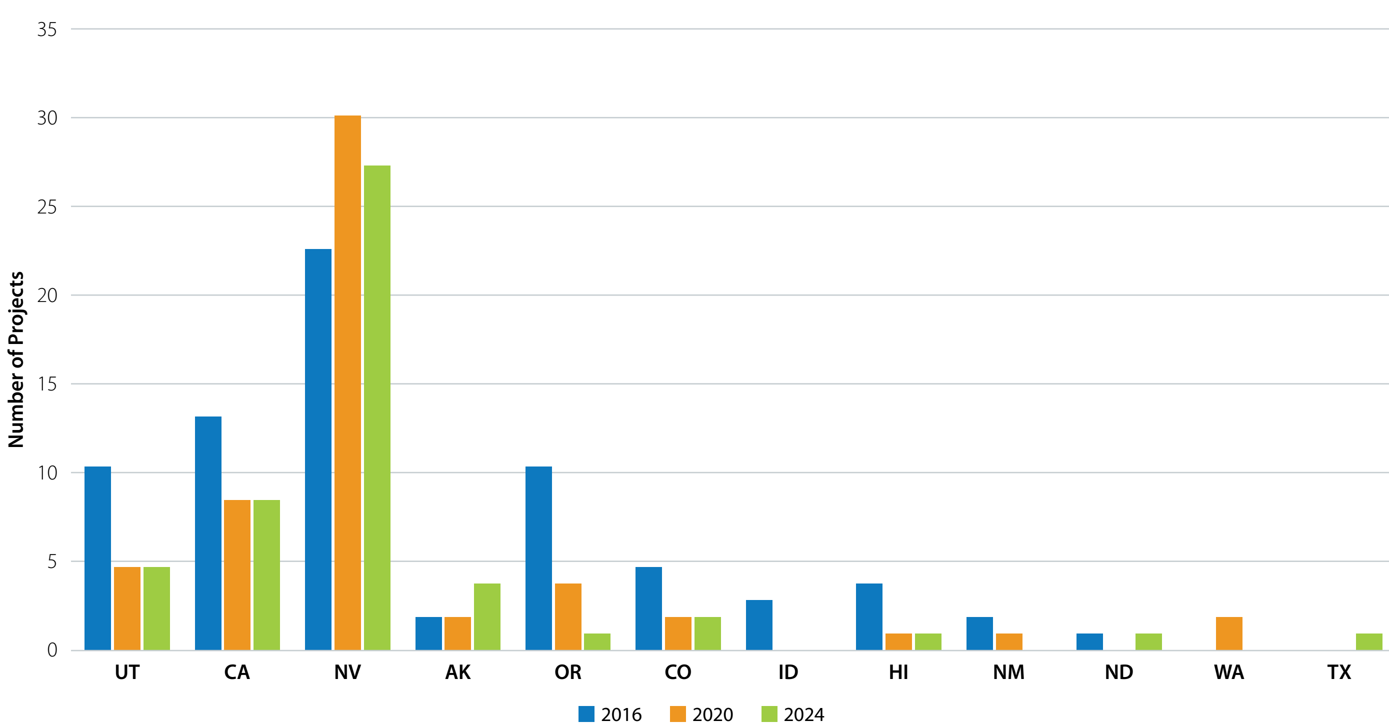

Figure 11. U.S. geothermal developing projects by state as reported in the 2023 industry survey with additions confirmed by NLR analysts. *This chart includes data that were not reported in the 2023 industry survey but were confirmed as being in development through investigation by NLR analysts.*

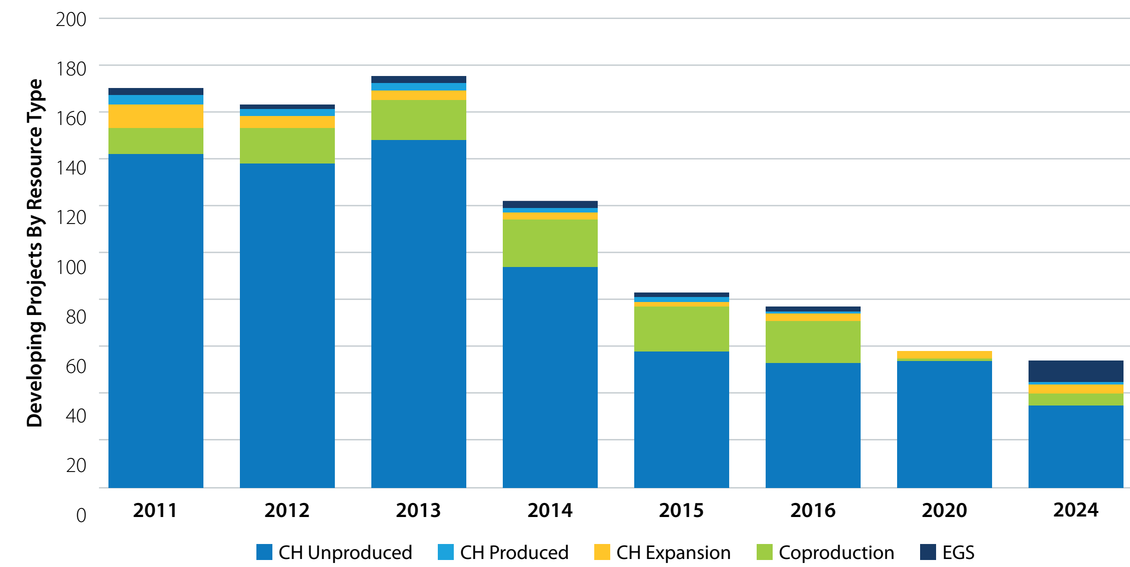

Figure 12. U.S. geothermal developing projects by resource type as reported in the 2023 industry survey with additions confirmed by NLR analysts. *This chart includes data that were not reported in the 2023 industry survey but were confirmed as being in development through investigation by NLR analysts.*

drilled (78) or spudded[12] (9) between early 2020 and September 2024 in the conterminous United States. An additional 20 wells have been approved and are pending drilling. This equates to an average of 21 wells drilled per year based on the total number of wells. The greatest number of wells drilled, spudded, or approved for drilling during this period has been in Nevada (38), followed by Utah and California with 35 and 30 wells, respectively. Most wells were production (42) or injection (42) wells. Within the period assessed, Utah experienced the largest growth in wells—from no new wells drilled in 2020 to 35 wells in 2024. Figure 13 shows the status of U.S. wells as of September 2024. The status "EGS" represents the wells drilled as part of Fervo's Cape Station project in Utah. The "EGS Research" wells are the production

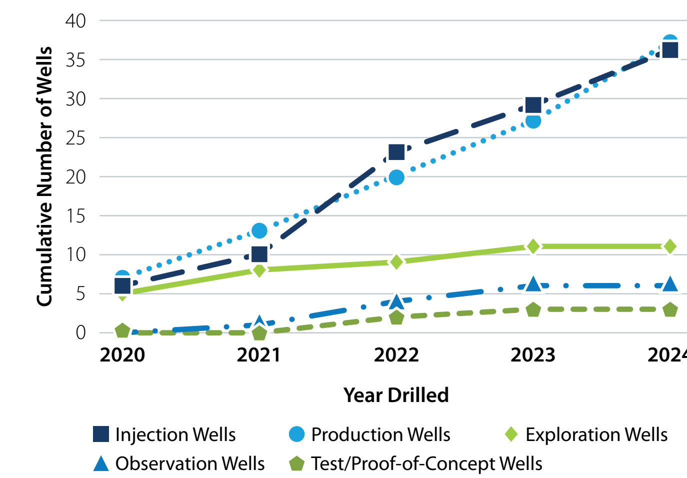

Figure 14. New U.S. geothermal wells by year and type

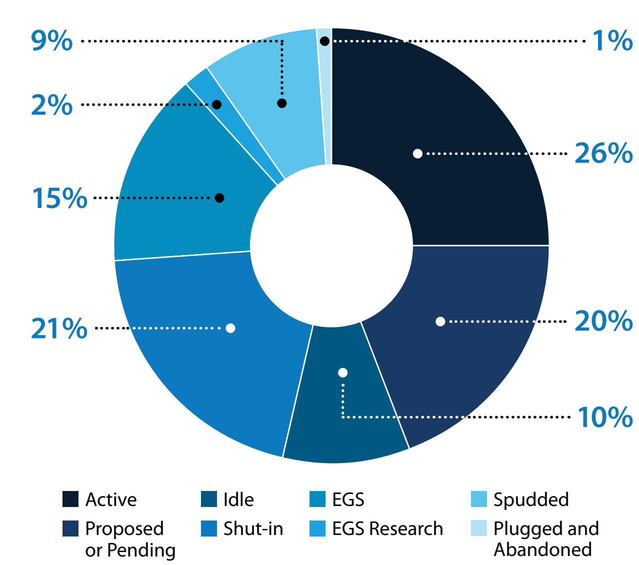

Figure 13. Status of new U.S. geothermal wells drilled since 2020

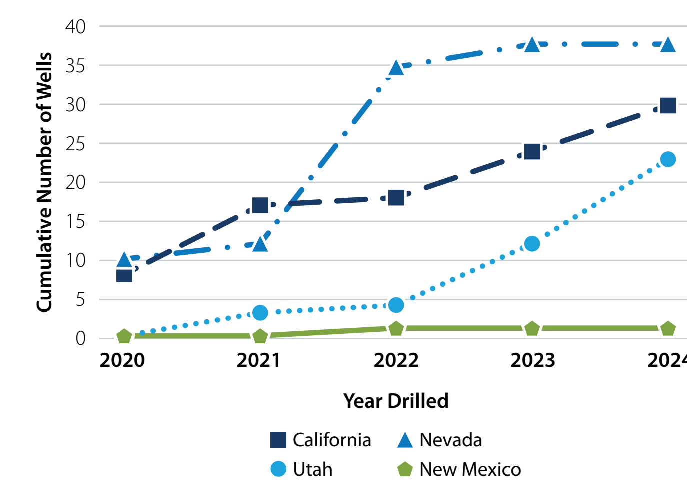

Figure 15. Cumulative new geothermal wells by U.S. state and year since 2020

[12] Spud refers to the initial stages of the drilling process. Once the main drilling bit has penetrated the ground surface, the well has been spudded.

TABLE 3. U.S. Geothermal PPAs Since 2021 Geothermal Market Report

Project	Purchaser	Operator	Technology	State	Size [MW]	Pricing [$/MWh]	Term [yrs]	Year Signed	CPUC Order (Yes/No)	Sources
Heber South	Clean Power Alliance	Ormat	Conventional	CA	14	Undisclosed	15	2021	No	Richter (2021)
The Geysers—San Mateo	Peninsula Clean Energy	Geysers Power Company/Calpine	Conventional	CA	35	Undisclosed	10	2021	No	Cariaga (2021)
North Valley	NV Energy	Ormat	Conventional	NV	25	Undisclosed	25	2021	No	Cariaga (2022a)
Heber 2	Peninsula Clean Energy	Ormat	Conventional	CA	26	Undisclosed	15	2022	Yes	Cariaga (2022b)
The Geysers—Sacramento	Sacramento Municipal Utility District	Geysers Power Company/Calpine	Conventional	CA	100	99	10	2022	No	Richter (2022a)
Fish Lake	California Community Power	Open Mountain Energy	Conventional	CA	13	Undisclosed	20	2022	Yes	Kaishan Group (2022a)
Bottle Rock	Marin Clean Energy	Open Mountain Energy	Conventional	CA	7	Undisclosed	21	2022	Yes	Kaishan Group (2022b)
Cape Station—SoCAL CCAs	9 California Community Choice Aggregators (CCAs)	Fervo	Next Generation	CA	30	Undisclosed	15	2022	Yes	Cariaga (2022c; 2025a)
Churchill County	Ava Community Energy	Fervo	Next Generation	CA	40	Undisclosed	40	2022	Yes	Richter (2022b)
Developing Plants	California Community Power	Ormat	Conventional	CA	125	Undisclosed	20	2022	Yes	Cariaga (2022d); Ormat (2022)
Nevada Expansion	NV Energy	Ormat	Conventional	NV	120	Undisclosed	25	2022	No	Cariaga (2022a)
Eavor EGS	NV Energy	Eavor	Next Generation	NV	20	Undisclosed	Undisclosed	2022	No	Eavor (2024c)
Blue Mountain	Google	Fervo	Next Generation	NV	3.5	Undisclosed	12	2022	No	Cariaga (2024a); Reuters (2024)
Humboldt House	Marin Clean Energy	Open Mountain Energy	Conventional	NV	20	Undisclosed	21	2022	No	CALCCA (2024); Open Mountain Energy (2025)
Whitegrass 2	Peninsula Clean Energy	Open Mountain Energy	Conventional	CA	6	Undisclosed	20	2023	Yes	Cariaga (2023a); Kaishan Group (2022b); Peninsula Clean Energy (2022)
The Geysers—Calpine	North California Power Agency	Geysers Power Company/Calpine	Conventional	CA	100	Undisclosed	12	2023	No	Cariaga (2023b)
Puna	Hawai'i Electric Light Co.	Puna Geothermal Venture/Ormat	Conventional	HI	46	Undisclosed	30	2023	No	Cariaga (2023c; 2024e)
Oakland—Calpine	Port of Oakland	Calpine	Conventional	CA	2	70	12	2023	No	Cariaga (2023b)
Cape Station—SCE	Southern California Edison (SCE)	Fervo	Next Generation	CA	320	Undisclosed	15	2024	Yes	Cariaga (2024f)
NV Energy Google Data Center*	Google	Fervo	Next Generation	NV	115	Undisclosed	6	2024	No	Cariaga (2024a)
Meta Data Stations*	Meta Platforms Inc.	Sage Geosystems	Next Generation	TBD	150	Undisclosed	Undisclosed	2024	No	Cariaga (2024d)
Cape Station CPA add-on	Clean Power Alliance (CPA)	Fervo	Next Generation	CA	18	Undisclosed	15	2025	Yes	Cariaga (2025b)
Mammoth 2	Calpine Energy Solutions	Ormat	Conventional	CA	15	Undisclosed	10	2025	No	Richter (2025a)
Cape Station—Shell	Shell Energy North America	Fervo	Next Generation	CA	31	Undisclosed	15	2025	Yes	Power Technology (2025); Richter (2025b)
Presidio County	Presidio Municipal Development District (PMDD)	Exceed Geo Energy	Next Generation	TX	110	Undisclosed	Undisclosed	2025	No	Exceed Geo Energy (2025); Cariaga (2025c)
Meta Data Center*	Meta Platforms Inc.	XGS	Next Generation	NM	150	Undisclosed	Undisclosed	2025	No	Johnson (2025)

* Energy supply or project development agreement, not within the classic definition of a PPA.

and injection wells at the Utah FORGE site. Figure 14 shows the type of geothermal wells that have been drilled since 2020, and Figure 15 depicts the state in which they were drilled.

3.2.5 Power Purchase and Other Offtake Agreement Activity

The recent growth in the geothermal industry is illustrated in Table 3, listing 26 new geothermal PPAs and offtake agreements signed since the beginning of 2021 through June 2025. Together these represent commitments for over 1,640 MWe of new capacity in the coming years. Many of these projects will be located in California and Nevada, and range in generation size from 2–320 MWe. While many of these PPAs target undeveloped resources, there are also notable expansions to established fields such as The Geysers in California and Puna in Hawai'i. In addition, Fervo Energy has entered into a first-of-its-kind agreement with NV Energy and Google, agreeing to produce 115 MWe of energy to Google's data centers by 2030 (see Section 3.7 for more information on data centers). This agreement centers around an alternative commercial model to the PPA that streamlines investment in baseload energy generation while avoiding transmission tie-in requirements and delays (Cariaga, 2024b). In addition, this commercial model does not place any project development cost burden on the participating utility's rate base as Google takes on the premium costs. Next-generation geothermal systems account for 60% of the PPAs. As of June 2025, utilities have procured (or agreed to procure) 984 MWe of next-generation geothermal power capacity across California (439 MWe), Nevada (135 MWe), New Mexico (150 MWe), Texas (110 MW) and an undisclosed location east of the Rocky Mountains (150 MWe) through 11 PPAs.

As mentioned at the beginning of Section 3, the 2021 CPUC order has contributed to the growth of PPAs in California. The order requires load-serving entities within its jurisdiction to collectively procure at least 1 GWe of firm, high-capacity factor resources by 2026, including geothermal resources, which can be imported

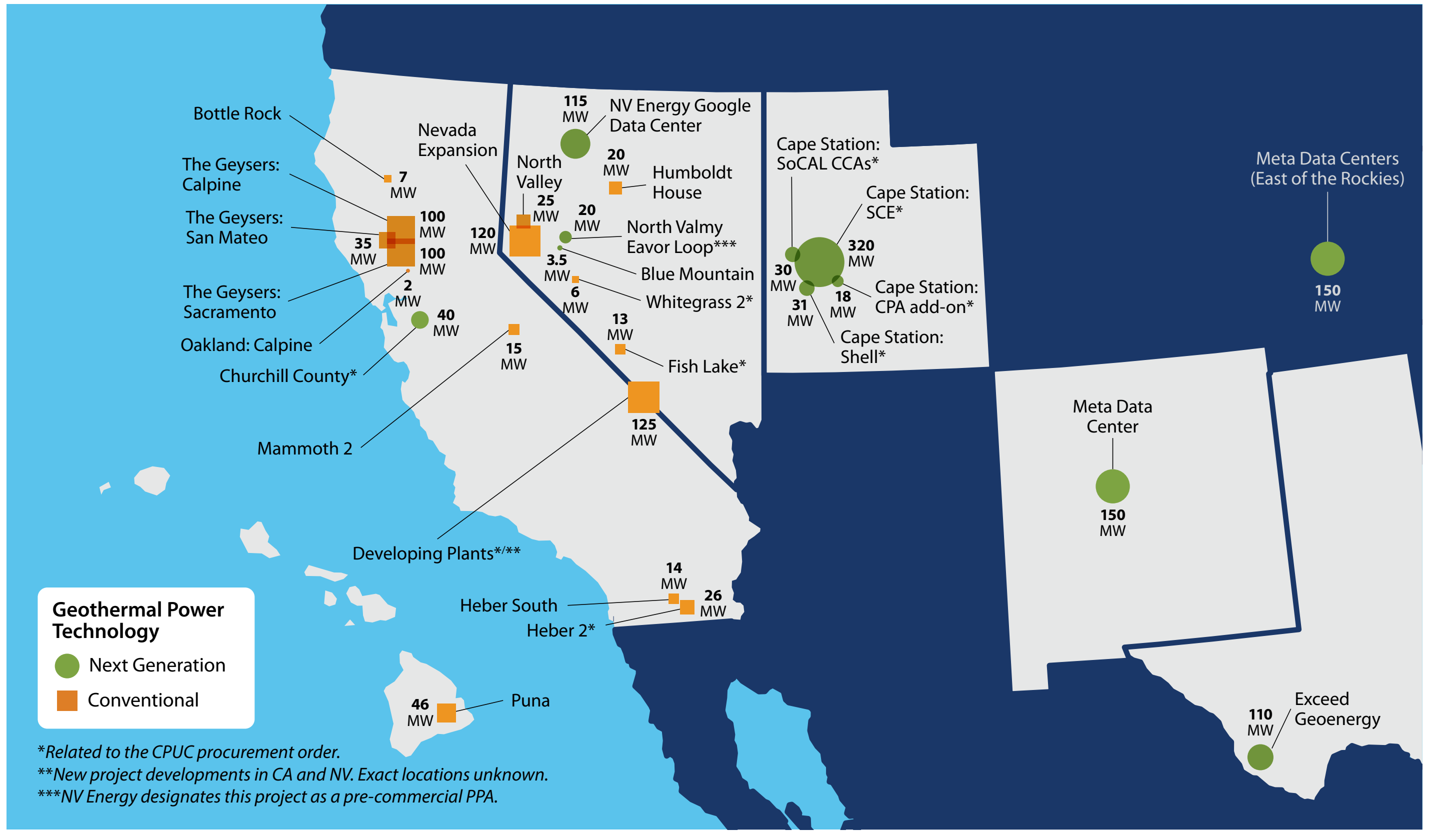

Figure 16. New geothermal power project developments within PPAs signed between 2021 and July 2025, including those related to the 2021 CPUC procurement order. *Data from multiple sources; see Table 3 for more information. Note that CCA stands for Community Choice Aggregator, SCE stands for Southern California Edison, and CPA stands for Clean Power Alliance.*

from other states (CPUC, 2021). Following the mid-term reliability obligations mandated in this order, there have been 15 PPAs (totaling 853 MWe of procured power capacity since 2022) signed as of June 2025 between conventional and next-generation geothermal developers and investor-owned utilities, energy service providers, and community choice aggregators in California. NLR researchers found association between 11 of these PPAs and the 2021 procurement order, resulting in the promise of at least 984 MWe (Figure 16). Other PPAs may be resultant of the 2021 procurement order but have not reported any connection.

In August 2024, CPUC published a decision that determined the need for the consolidation of procurement of renewable long-lead-time[13] resources through the California Department of Water Resources (CPUC, 2024). This rule is anticipated to spur and streamline the procurement of an additional 1 GWe of long-lead-time geothermal resources with delivery dates between 2031 and 2037.

3.2.6 Updates on Developing Projects Since 2020

At the time of the 2021 Geothermal Market Report, there were 61 projects in various stages of development. Of these, 29 have been discontinued, 25 are still in progress, and 5 have been completed and are now operational (Figure 17). Ormat accounted for many of the previously active projects and those that were ultimately discontinued. Notably, 18 of Ormat's 20 discontinued projects were in the very early stages of development, classified as Prospect or Phase I (see Section 2.1). This pattern reflects Ormat's strategy of pursuing numerous relatively low-temperature resources, made possible by their proprietary binary power cycle technology.

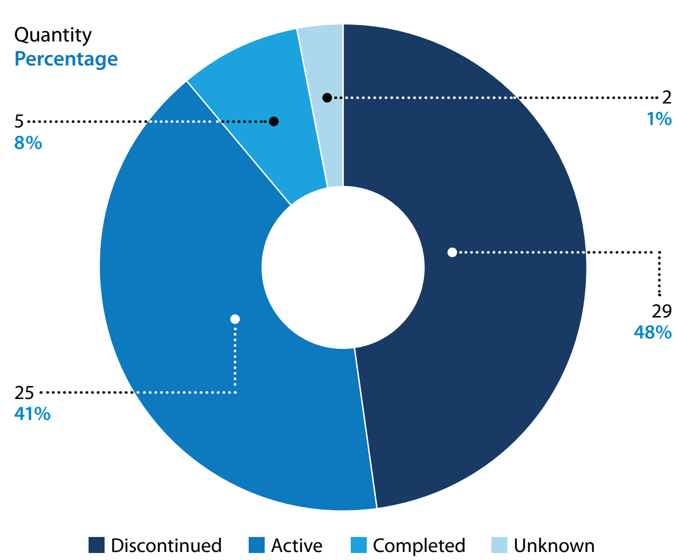

Figure 17. Status of 2020 developing projects as of 2024

[13] A long-lead-time resource is one that has a construction and development lead time of at least 5 years.

3.2.7 Federal Incentives Updates

Since the 2021 Geothermal Market Report, there have been updates to federal incentives available for geothermal power projects. The Inflation Reduction Act of 2022 (IRA) extended the eligibility of the federal Production Tax Credit (PTC) date of construction for geothermal facilities through 2024. This included additional bonuses for facilities meeting specific manufacturing and project locations. The PTC ended in 2024 with a technology-neutral tax credit (i.e., Section 45Y) taking its place beginning in 2025. Taxpayers may choose between the technology-neutral tax credit (i.e., Section 45Y) and an Investment Tax Credit (ITC) (i.e., Section 48E). As of July 4, 2025, geothermal projects utilizing Section 45Y can have a later placed-in service deadline, effectively extending the PTC for geothermal facilities through 2036 (H.R.1 2025). The full credit is available for facilities that begin construction by the end of 2033, with a phased down credit beginning in 2034 and is repealed in 2036. For the ITC or Section 48E, the credit will also be available for facilities with construction commencing by the end of 2033, with a phase down beginning in 2034 and is repealed in 2036 (H.R.1 2025). Further information on geothermal incentives including state and federal incentives can be found in Section 5.

3.3 Cost Trends

The costs to identify, delineate, confirm, and develop a geothermal resource are important in decision-making, both in the government and private sector investment space. DOE has implemented or initiated several efforts in the past decade to improve subsurface exploration and field development costs by de-risking certain activities that heavily influence these costs. To accelerate progress in geothermal resource exploration, DOE funded the Play Fairway Analysis portfolio[14] and the Hidden Systems portfolio[15] to lessen the uncertainty in discovering and estimating hidden resources, and the Geothermal Manufacturing Prize[16] to support the development and deployment of advanced tools for subsurface data collection. To de-risk drilling, completion, and stimulation activities for next-generation geothermal development, DOE funded the EGS Collab[17] project and funds the Utah FORGE[18] project. The EGS Collab included eight national laboratories, six universities, and multiple industrial partners. These two efforts have provided enhanced performance data and validation of state-of-the-art techniques and tools such as hydraulic planar fracturing of hard rock, multistage stimulation with zonal isolation, polycrystalline diamond compact drill bits, and insulated drill pipes. Other private sector projects, including Fervo's Project Red in Nevada (Norbeck and Latimer, 2023) and Project Cape in Utah (Norbeck et al., 2024), have validated the multi-well pad drilling technique in hard rock and recorded industry leading drilling times and reservoir stimulation performance. These efforts have resulted in year-on-year reduction in geothermal costs.

3.3.1 Cost Drivers

Geothermal electricity production costs comprise the costs to develop both subsurface infrastructure as well as the surface power conversion system. Some of the component costs are intrinsic to geothermal (e.g., water-steam separator in flash power plant) while others are affected by externalities or activities in other complementary industries (e.g., the daily rigs rate of a drilling rig). Costs are also categorized based on the type of resource that produces the thermal energy—hydrothermal, EGS, and CLG—and the surface power conversion system—dry steam, flash, or binary power cycle. Historically, hydrothermal plays have been the dominant type; hence, geothermal electricity costs have been tied to the cost of conventional hydrothermal development. As resource availability increases for next-generation technology development beyond hydrothermal plays, cost profiles for geothermal are becoming technology specific.

Figure 18 shows the capital cost (CAPEX) and operation and maintenance (O&M) cost for hydrothermal and EGS technologies based on data from NLR's Annual Technology Baseline (ATB; see NLR, 2024). The ATB provides present technology-specific cost and performance parameters, in addition to future projections through 2050. As a mature technology, the hydrothermal (flash and binary) system costs have remained relatively stable. EGS technologies have historically been characterized by higher CAPEX relative to conventional hydrothermal systems. This is because historical EGS costs have been based on experience with previous U.S. (e.g., the Fenton Hill project) and international (e.g., Soultz-sous-Forêts, in France) demonstration projects that have yielded low performing reservoir productivity and thermal energy production relative to the cost for field development. However, as shown in Figure 18, these costs have been

[14] https://www.energy.gov/eere/geothermal/play-fairway-analysis
[15] https://www.energy.gov/eere/geothermal/hidden-systems
[16] https://www.energy.gov/eere/articles/doe-announces-geothermal-manufacturing-prize-winners
[17] https://www.energy.gov/eere/geothermal/egs-collab
[18] https://utahforge.com/

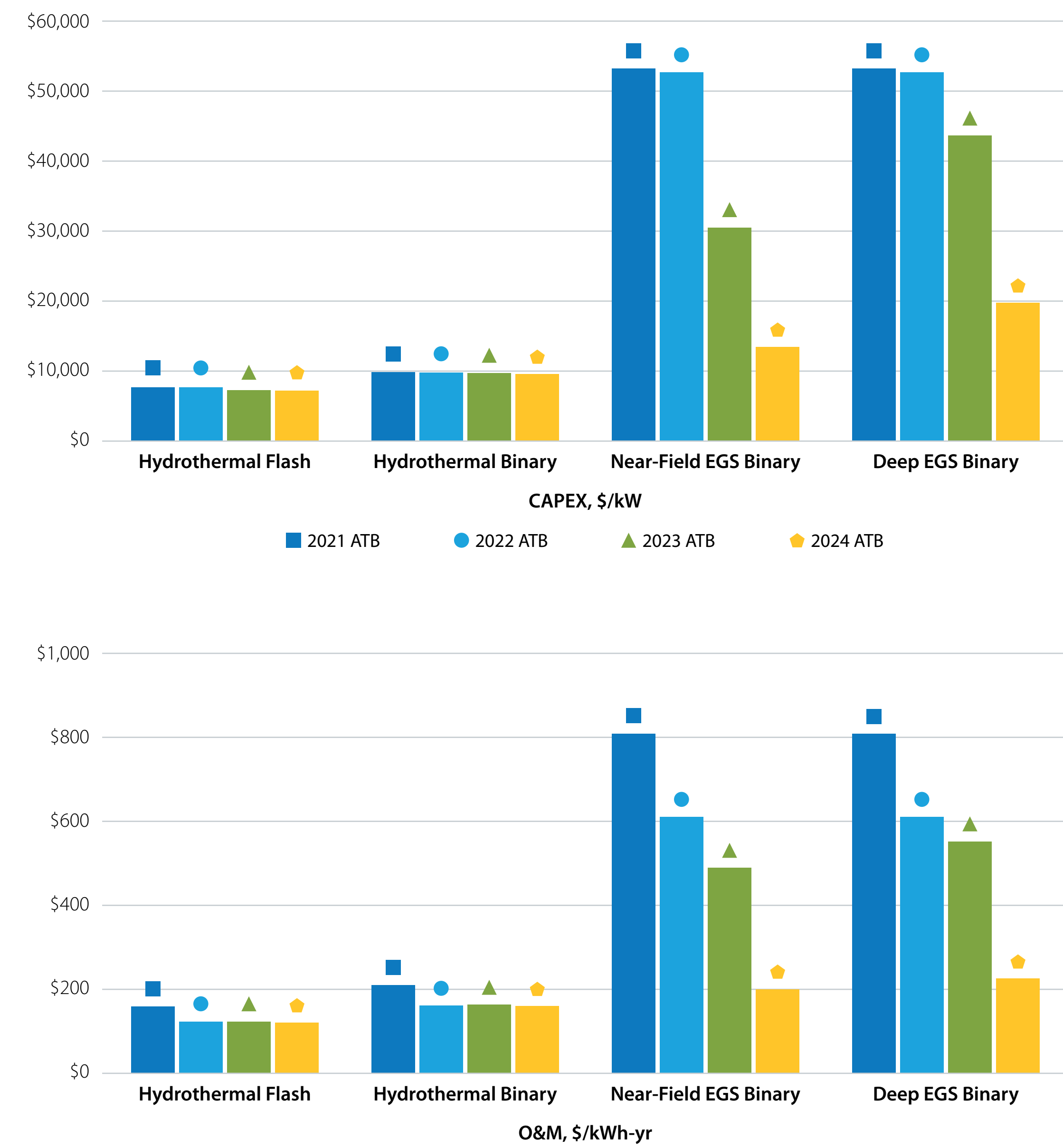

Figure 18. CAPEX (top) and O&M costs (bottom) for hydrothermal and EGS technologies from the 2021 ATB to the 2024 ATB. *All costs are in 2022 dollars (the base year for the 2024 ATB).*

declining significantly over 2023 and 2024 as a result of an uptick in EGS development projects. An example of this is the commercial-scale (3.5-MWe) well doublet installed in 2023 at the Blue Mountain Geothermal Plant in Nevada (i.e., Fervo's Project Red). Figure 18 shows that the CAPEX costs of the deep (3–7 km) EGS binary case decreased from 53,240 $/kW in the 2021 ATB to 19,757 $/kW in the 2024 ATB, and O&M costs decreased from 808 $/kWh-yr to 226 $/kWh-yr over the same period. In the near-field EGS binary case, CAPEX costs decrease from 53,240 $/kW to 13,415 $/kW and O&M costs decrease from 808 $/kWh-yr to 200 $/kWh-yr from 2021 to 2024. Project Red, the EGS Collab, the Utah FORGE EGS demonstration project, the Cape Station project, and other industry pilot projects are de-risking EGS technology developments by reducing the uncertainty around viable reservoir creation through effective hydraulic fracturing and by applying state-of-the-art drilling technologies. The associated drilling performance improvements are also anticipated to reduce the cost of conventional hydrothermal field development.

3.3.2 Capital Cost by Activity

Geothermal project development undergoes different phases characterized by specific activities as described in Section 2.1.4. This section discusses the most cost-intensive activities, including exploration, drilling and completion, stimulation, field gathering system installation, and engineering and power plant construction.[19]

[19] These are based on project cost classifications used in the ATB analysis and not on any regulatory standard. BLM defines geothermal project phases as Exploration, Drilling, Utilization, and Reclamation (https://www.blm.gov/programs/energy-and-minerals/renewable-energy/geothermal-energy).

The project CAPEX is a function of the overnight capital cost and the cost to finance the project (i.e., the cost of capital). The overnight capital costs vary by geothermal resource and power plant technology. Figure 19 shows the percentage breakdown of overnight capital costs according to the project activities for hydrothermal and both near-field and deep EGS based on the analysis of representative sites[20] in the 2024 ATB. The charts show that the dominant cost-intensive activity for hydrothermal project development is engineering and plant construction (58% for flash, 61% for binary), while drilling and completion (i.e., full-sized well drilling for resource confirmation and full field development, excluding stimulation) is the most cost-intensive activity for deep EGS (57%). For near-field EGS projects, which tend to be sited proximal to a developed hydrothermal field (i.e., a brownfield) as in the case of Fervo's Project Red in Nevada, there is less of a requirement for exploration and a lower uncertainty in resource confirmation. Therefore, the cost for plant construction (48%) dominates the cost profile.

3.3.3 Drivers for Drilling Cost Reductions

Based on the cost breakdown in Figure 19, drilling costs range from 29% to 57% of the total cost of developing a geothermal field. Therefore, cost reductions in drilling and completion activities can have a significant impact on project capital costs. Historically, geothermal well costs were similar to oil and gas well costs on a cost per footage drilled basis despite mostly drilling into hard (igneous and metamorphic) rocks compared to sedimentary formations targeted by oil and gas projects (Augustine et al., 2006). However, recently, oil and gas wells have become cost-competitive because of advances in bit technology and efficiency improvements facilitated by the drilling of millions of onshore wells in unconventional oil and gas plays. The cost reductions are evident even though more than 90% of new oil and gas wells are drilled horizontally (Leveille, 2025), which can add complexity to the drilling process but increases reservoir contact and well production capabilities. Geothermal drilling has also seen a decrease in drilling costs in recent years, although drilling geothermal wells is still more expensive than oil and gas wells. More specifically, demonstration and commercial projects to de-risk EGS drilling—including the Utah FORGE project and Fervo's Project Red and Cape Station drilling campaigns—have resulted in notable geothermal drilling performance, efficiency, and cost improvements. For example, drilling rates at Utah FORGE have improved by more than 500% since 2017 (Dupriest and Noynaert, 2024). Figure 20(a) tracks the drilling rates (feet of measured depth [ft MD] per on-bottom hour) of five wells drilled at the Utah FORGE site, showing the decrease in on-bottom hours with each well and a trajectory toward oil and gas drilling rates

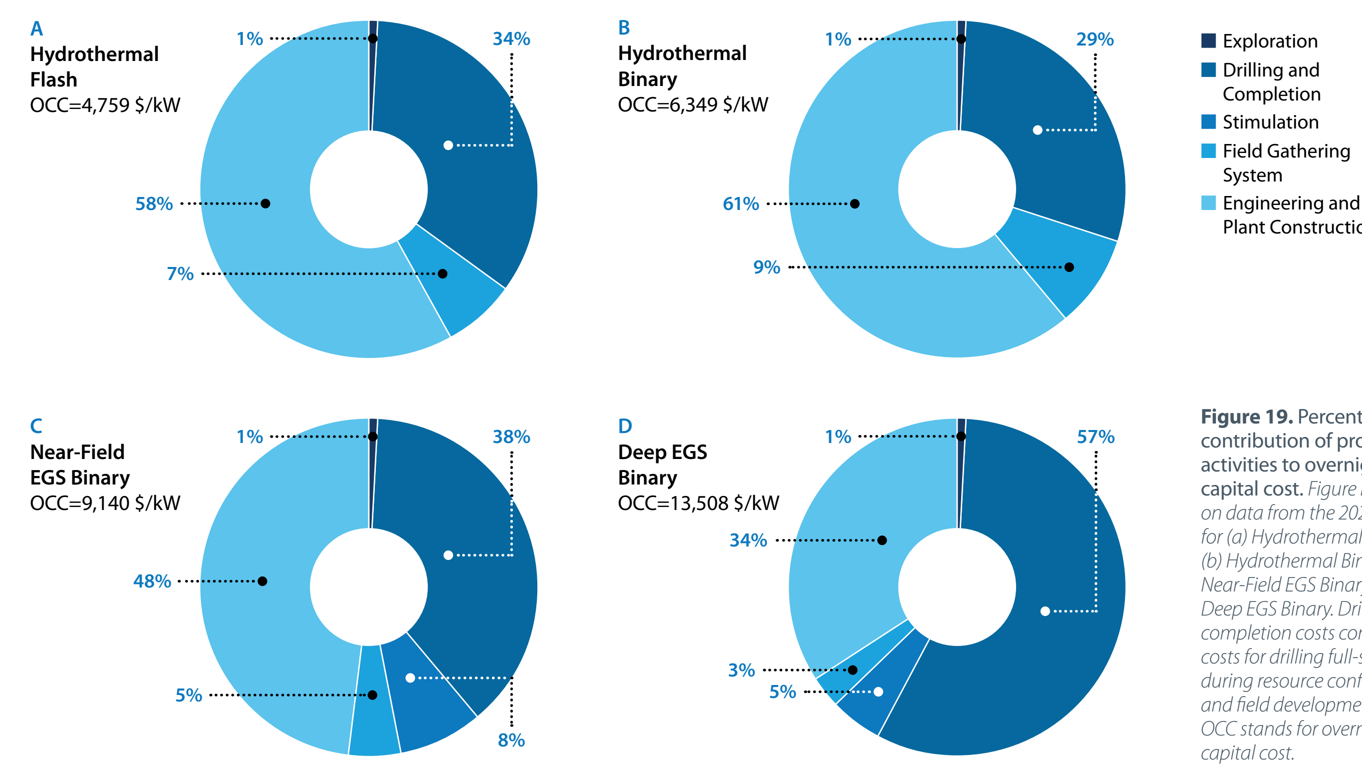

Figure 19. Percentage contribution of project activities to overnight capital cost. *Figure is based on data from the 2024 ATB for (a) Hydrothermal Flash, (b) Hydrothermal Binary, (c) Near-Field EGS Binary, and (d) Deep EGS Binary. Drilling and completion costs comprise the costs for drilling full-size wells during resource confirmation and field development. Note OCC stands for overnight capital cost.*

[20] The assumptions for representative sites in the 2024 ATB can be found in "Representative Technology" section of the ATB documentation website (https://atb.nrel.gov/electricity/2024/geothermal).

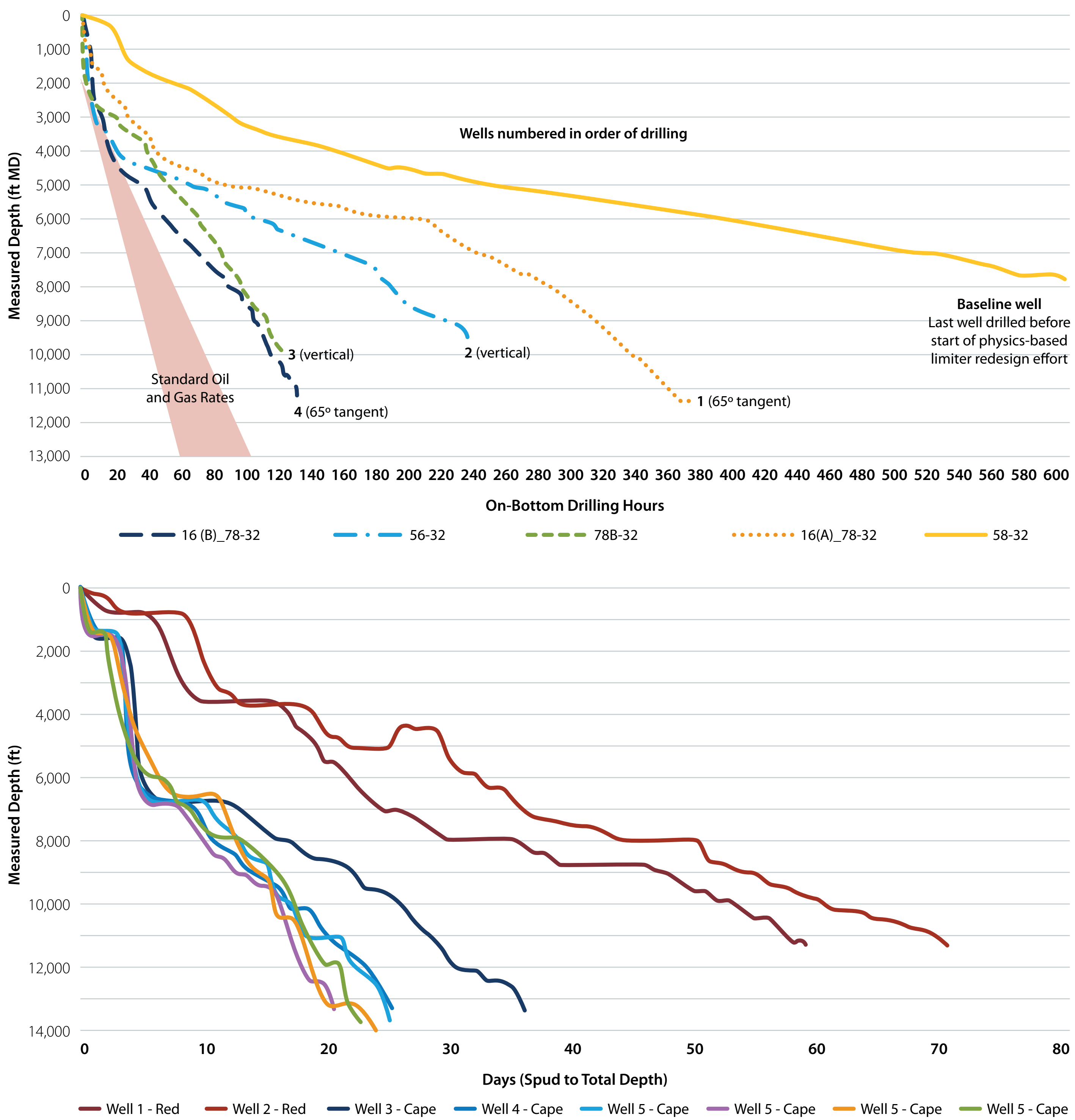

Figure 20. Drilling rates at Utah FORGE (top) and Fervo's Project Red in Nevada (bottom). *(top) On-bottom time versus measured depth for five wells drilled at Utah FORGE between 2017 (58-32) and 2023 (16B(788)-32) showing remarkable improvement in drilling rates (Dupriest and Noynaert, 2024). (bottom) Days versus measured depth curves for Fervo's Project Red in Nevada and six Cape Station wells in Utah (El-Sadi et al., 2024). Sources: (top) Figure recreated from Dupriest and Noynaert (2024), with permission from One Petro; (bottom) figure recreated from El-Sadi et al. (2024), with permission from Fervo.*

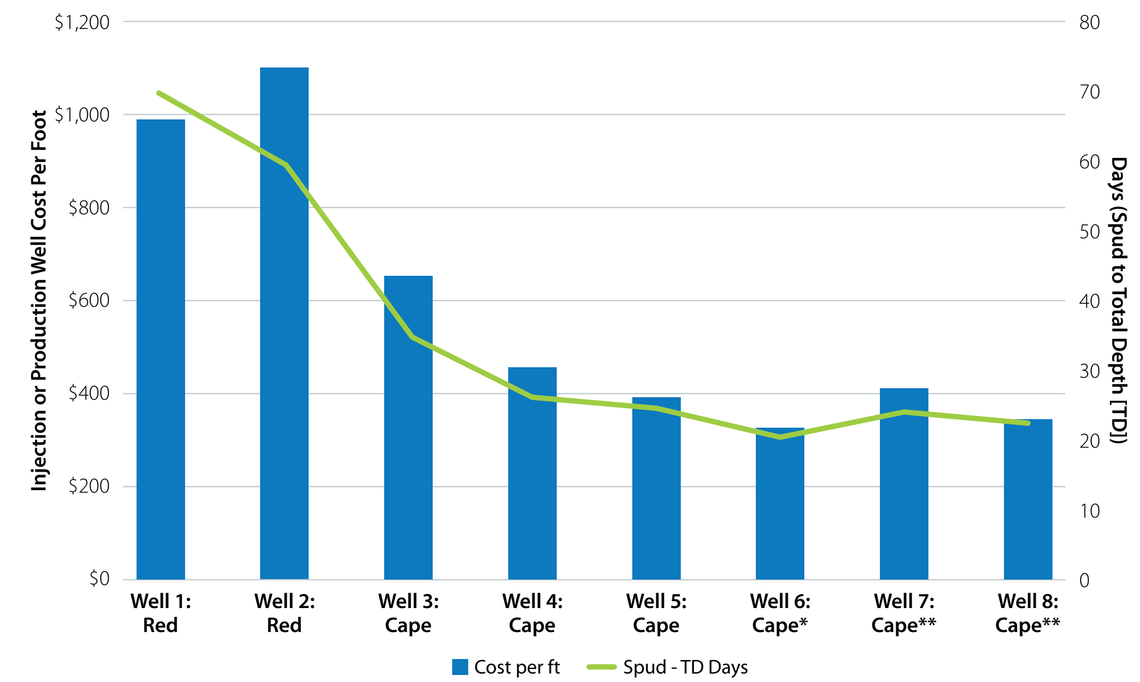

Figure 21. Cost per foot (blue bars) and total drilling days from spud to total depth (green curve) for Fervo's Project Red in Nevada and six Cape Station horizontal wells in Utah. *Data from El-Sadi et al. (2024).*

(the shaded wedge). The shorter drilling time leads to less costs associated with labor, equipment usage, and overhead.

As of February 2025, Fervo has drilled 20 horizontal wells at Cape Station in Utah. Figure 21 shows the total drilling time versus measured depth curves for the two Project Red wells and the first six wells at Cape Station. The curves reveal significant inter-project and intra-project learnings. Specifically, substantial reduction in cost per footage drilled has been reported from an average of approximately $1,050/ft in Project Red to less than about $450/ft for the first six Cape Station wells (El-Sadi et al., 2024).[21] Advances in polycrystalline diamond compact bit design and use of physics-based techniques to optimize mechanical specific energy and maximize sustained rate of penetration are key factors in Fervo and Utah FORGE on-bottom drilling successes (Akindipe and Witter, 2025). These advanced drilling techniques, largely stemming from knowledge transfer from the oil and gas industry, are expected to benefit the entire geothermal sector—whether drilling horizontal or vertical wells.

3.3.4 Levelized Cost and Power Sales Price

Although not a perfect measure of technology cost and value, the levelized cost of energy (LCOE) is still the foremost standard for determining current levels of performance and commercial viability of geothermal technologies. Multiple organizations report short- to long-term costs for geothermal electricity. Figure 22 shows the LCOE estimates for mature (hydrothermal) technologies based on the data from the 2024 ATB (Conservative, Moderate, and Advanced Scenarios), Lazard's LCOE+ reports, the EIA, the International Renewable Energy Association (IRENA), and the International Energy Agency (IEA) (NLR, 2024; Lazard, 2024; EIA, 2023b; IRENA, 2024). For 2023, the Lazard minimum and maximum estimates mostly aligns with the ATB year 2023 forecasts. The IRENA and IEA estimates take account of global geothermal deployments in 2023 and are influenced by a recent uptick in new hydrothermal plant installations in Asia. The EIA Annual Energy Outlook for new generation resources expected to come online by 2028 predicts an LCOE within the range of $41–$47/MWh, which is much more aggressive than the ATB Advanced scenario and the NLR-published Enhanced Geothermal Shot Analysis target (i.e., $45/MWh by 2035) (Augustine et al., 2023b). Despite their variations, all forecasts consistently indicate a downward trend in geothermal costs.

Based on data from the ATB in recent years, the LCOE of conventional hydrothermal systems has not changed significantly in recent years, ranging from $63–$74/MWh for flash and $90–$110/MWh for binary plants (see Figure 23). Given the willingness of energy purchasers to pay for firm, high-capacity-factor and reliable geothermal electricity, and noting the range of PPA pricing reported in Table 3 ($70–$99/MWh), these ranges of LCOE are considered investable. As of 2024, Ormat is negotiating $100/MWh (200 MWe) portfolio

[21] Proprietary data from Fervo reveals that some subsequent Cape Station wells were drilled at a cost below $300 per foot. For comparison, oil and gas well construction costs are between $143 and $245 per foot in the Permian Basin (https://www.pheasantenergy.com/the-numbers-the-permian-excels/).

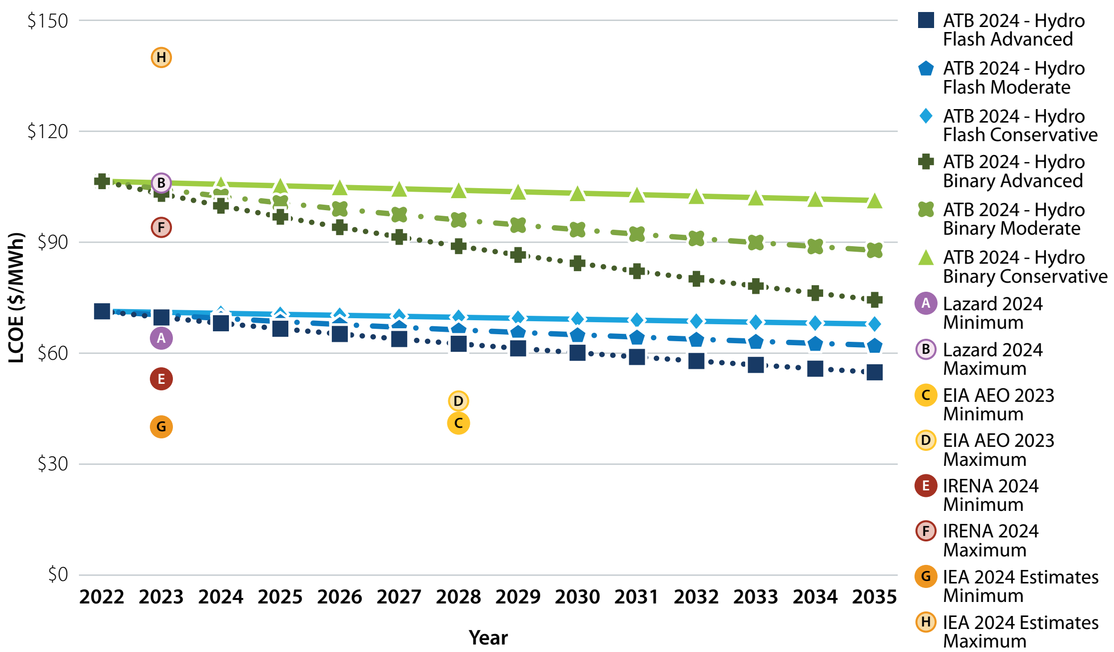

Figure 22. The LCOE for mature geothermal power installations. *Figure is based on data from the 2024 ATB, Lazard 2024 LCOE+ (2023 costs), EIA Annual Energy Outlook (2028 forecast), IEA (2023 costs), and IRENA (2023 costs). All data are for unsubsidized cost (i.e., without tax incentives).*

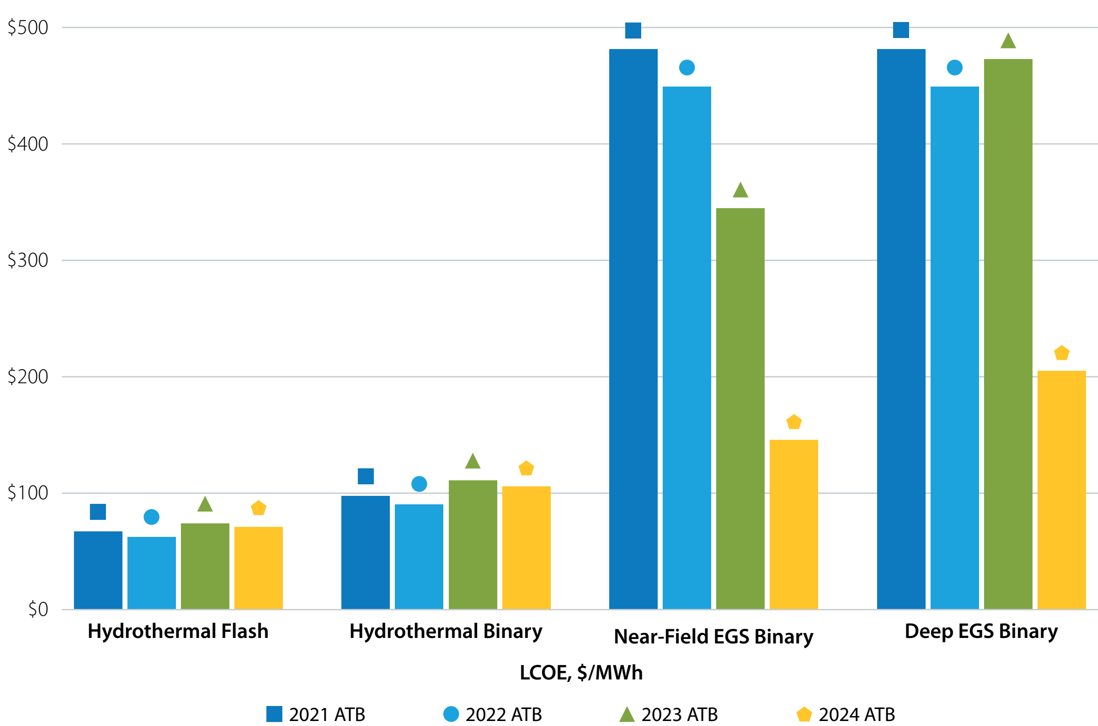

Figure 23. The LCOE for geothermal power technologies from the 2021 ATB to the 2024 ATB. *All costs are in 2022 dollars.*

PPAs and anticipates a rise in geothermal PPA prices in the near term (Ormat, 2024b).

With recent EGS advances, EGS LCOE is declining and has the potential to hit levels of today's conventional hydrothermal within the next decade (i.e., by 2035) based on the 2024 ATB Moderate Scenario. The latest outcomes from Fervo's drilling, stimulation, and well testing activities at their Cape Station site have given insight into this possibility. For example, the maximum production rate recorded during the 30-day flow test at Cape Station has surpassed the assumption for the 2024 ATB Advanced scenario (i.e., 120 kg/s at Cape Station vs. 110 kg/s in ATB) (Norbeck et al., 2024), indicating that key performance metrics are advancing quickly in geothermal development. Also, Fervo's published drilling costs as of 2024 are equivalent to the 2024 ATB Moderate Scenario cost curve in 2035.

3.4 Geothermal Power Development on Public Land

3.4.1 Geothermal Resources on Public Land

All currently operating geothermal plants in the United States are primarily hydrothermal plants and mostly concentrated in the West, where 90% of total U.S. public lands are located. As of September 2023, the majority of operating geothermal power plants are on BLM lands, with 51 in operation and a combined installed capacity of 2,600 MWe (BLM, 2023b). Eight projects are currently (as of January 2025) in the permitting process with a potential power output of 234 MWe (BLM, 2025c). Recent geothermal lease sales in Nevada and Utah have broken records in terms of total revenue and average revenue per acre, respectively: (1) In 2024, 64 Nevada parcels totaling 217,866 acres were leased for $7.8 million, and (2) in 2025, all 14 Utah parcels listed totaling 50,961 acres were leased for $5.6 million (BLM 2024, 2025a).

Analysis published by NLR modeled potential geothermal deployment on BLM and U.S. Forest Service (USFS) lands for multiple combinations of geothermal resource depths and technologies through the year 2050 (Martinez Smith et al., 2024). The analysis identified high-opportunity geothermal leasing areas based on available data, using the updated reV model discussed in Section 3.1.1 and the Regional Energy Deployment System (ReEDS). At a high level, the analysis provides an estimated potential of geothermal energy that could be developed on BLM and USFS lands. This includes an estimated 3.9 TWe of hydrothermal resources and 8.8–15.4 TWe of EGS resources of new capacity in the conterminous United States. Within these resources, 1.4 TWe of hydrothermal and 4.35 TWe of EGS resources are estimated to be found on BLM and USFS land. Further analysis of these results indicates a smaller amount that is considered economically developable, including 2.3% (32 GWe) of hydrothermal resources and 1.1% (47.8 GWe) of EGS resources. The analysis identified that the highest potential of geothermal resources on BLM and USFS lease areas, based on future capacity deployment scenarios, is estimated to be 30.8 GWe for hydrothermal and 97.8 GWe for EGS.

NLR further updated geothermal potential in a 2025 report that analyzed wind, solar, and geothermal potential across all federally managed lands in the United States (Mai et al., 2025). NLR refined assumptions on technical exclusions with input and data from multiple federal agencies beyond BLM and USFS: the U.S. Fish and Wildlife Service, DoD, and DOE. This conterminous U.S.-scale analysis identified 975 GWe of EGS potential on federally managed lands.

3.4.2 Generating Capacity on Public Land

Public lands in the United States host many geothermal projects. Geothermal projects on public lands, predominately those managed by BLM, total 2,600 MW of nameplate capacity, with 756 MW added since 2000 (EIA, 2024a; Ormat, 2024a). In 2022, geothermal projects on BLM-managed land generated 11,098,954 MWh, enough to power more than 1.1 million homes, equivalent to the Hoover Dam (EIA, 2024a, 2024b, 2024c).

Figure 24 illustrates trends in installed geothermal nameplate capacity alongside existing and new leased acres from 2001 to 2024. Installed nameplate capacity shows steady growth, with a noticeable peak around 2012, after which the rate of increase slows slightly. This could indicate a shift in development pace or delays in bringing new projects online. New acreage leasing, represented by the blue bars, shows significant spikes around 2007–2009 and 2021–2024, suggesting periods of heightened interest in geothermal development, potentially driven by favorable policies, availability of federal government funding for geothermal development (e.g., through the American Recovery and Reinvestment Act of 2009), or market conditions. After 2009, there is a drop in new leased acres, particularly between 2010 and 2019, which may reflect economic challenges, regulatory hurdles, or limitations in resource identification. However, recent years have seen a resurgence in both leasing and capacity growth, likely due to increased demand for reliable baseload energy, technological advancements, and the presence of financial incentives including expanded

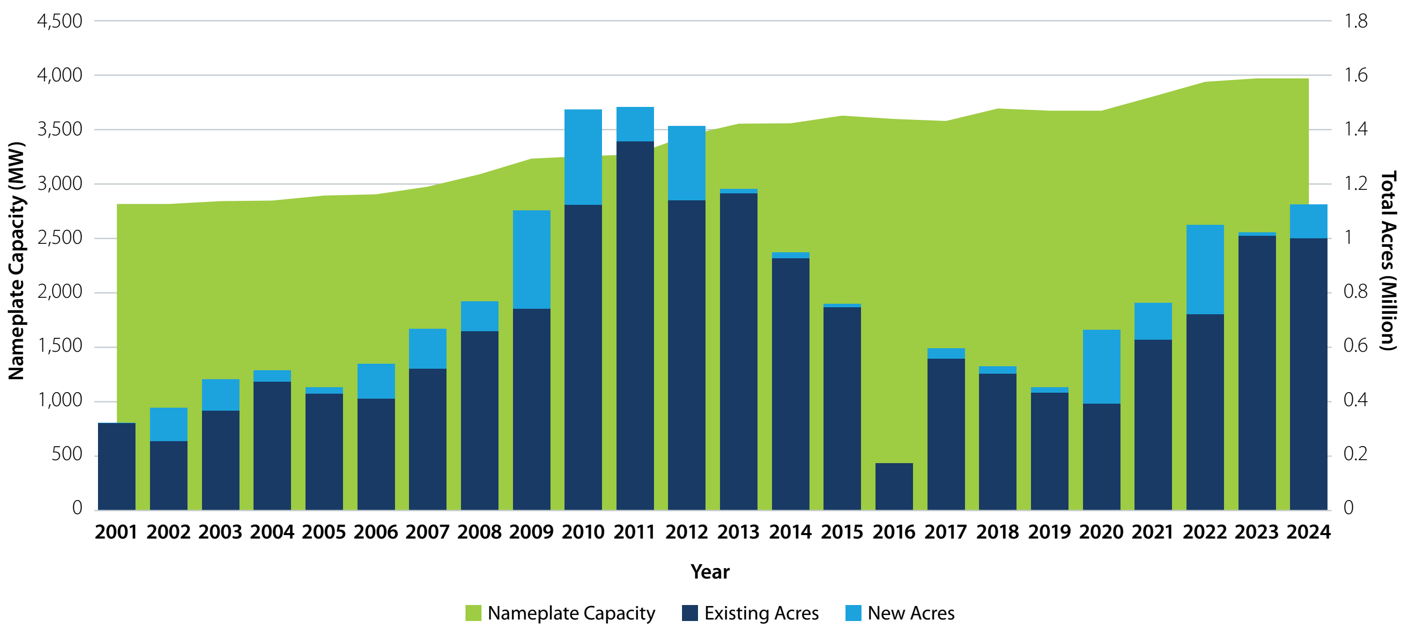

Figure 24. U.S. installed nameplate capacity (on federal, state, and private land), existing BLM leased acreage, and new BLM leased acreage. *Lease data from BLM Public Land Statistics.[22]*

tax credits. Throughout the period, the number of existing leased acres remains relatively stable, indicating strong land retention even during slower leasing periods. The chart reflects the cyclical nature of geothermal development, with external factors like policy and market dynamics influencing both leasing and capacity trends.

The total acreage shown in Figure 24 includes both competitive and noncompetitive leases[23] over time. As of January 2025, there were 568 leases managed by the BLM (BLM, 2025b). However, the 2016 data seem to have been inaccurately reported in the Public Land Statistics report (BLM, 2023a; 2025b), as they omit all 2005 Energy Policy Act (GPO, 2005) competitive leases and new leases (see Section 5.2.3). As a result, the 2016 total only reflects existing noncompetitive leases and competitive leases established before the 2005 Energy Policy Act.

3.4.3 Wells on BLM Acreage

The number of active production and injection wells and wells spudded annually on BLM leases since 2001 are illustrated in Figure 25.[24] The classifications for production and injection are self-reported by operators, including wells that have been shut-in, but excluding those that have been plugged. The 2005 Public Land Statistics report did not include well data, so it has been omitted. The spike in wells spudded during 2012 and 2013 roughly aligns with the increase in new leases from 2009 to 2012 (see Figure 25), factoring in the time required for permitting approvals. The decline in wells spudded after 2013 mirrors the stagnation in power production growth during that period. Additionally, between 2006 and 2008, there is a notable but unexplained drop in the number of production and injection wells, which may be partially due to reduced capacity in established geothermal fields or efforts to reclassify wells.

In recent years, there has been a notable increase in wells spudded, particularly during 2022 and 2023, despite a decrease in the total number of active injection and production wells. This trend suggests that while new wells are being drilled, older wells are most likely being shut-in, reclassified, or decommissioned, leading to a net reduction in active wells. The rise in wells spudded likely reflects efforts to maintain or expand capacity by replacing less productive wells with newer ones. However, the time required to drill, complete, and bring new wells online could explain the temporary decline in total operational wells. This could point to a transitional phase in geothermal operations, where new wells are still being developed to replace older wells but have not been comprehensively tested to determine productivity. It could also point to a situation where a proportion of the spudded wells was unsuccessful.

[22] https://www.blm.gov/about/data/public-land-statistics
[23] Competitive lease sales are required every two years in states where there are existing nominations of land parcels. Lease nominations can be submitted by a company or individual. For competitive leasing, the highest qualifying bid receives the leasing rights. Noncompetitive leases include lands that have previously been offered in a competitive lease sale, however, if they did not receive any bids they can be available for noncompetitive leasing for a two-year period on the first business day after the competitive sale. For noncompetitive leases, the first qualified applicant receives the leasing rights.
[24] Prior to 2001, the BLM received 20 lease applications between 1997 and 2001. Information on these applications has not been included in this report.

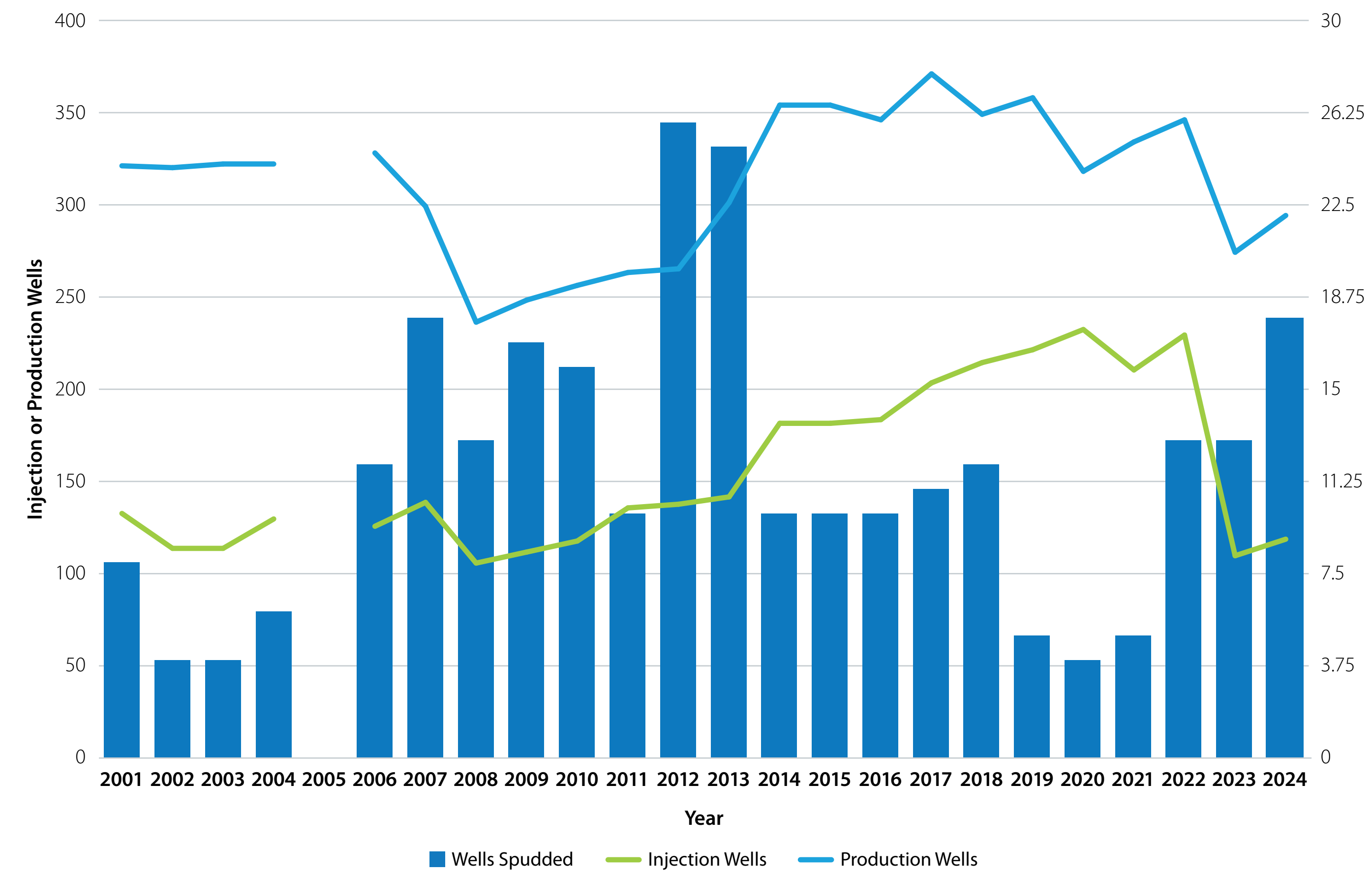

Figure 25. Number of wells spudded on leased BLM acreage, total number of active production wells, and injection wells on leased BLM acreage. *The 2005 Public Land Statistics report did not include well data, so it has been omitted.*

3.4.4 Geothermal Power Projects at U.S. Department of Defense Installations

Geothermal energy is an important part of U.S. energy security and energy independence. It is a domestic resource that can be harnessed by the U.S. workforce and uses existing U.S. supply chains. From a power perspective, geothermal energy can strengthen the electric grid and provide resilience against extreme weather, power outages, and cyberattacks, all with a small footprint. Several DoD projects and programs have the potential to impact the geothermal market. The power station at the Coso geothermal field at the Naval Air Weapons Station in China Lake, California, is currently the only geothermal power production on DoD lands. Coso has provided 36 years of continuous generation and over $550 million in revenue for the Navy (Sabin and Blake, 2023). Current generation capacity is 135 MWe of net electricity output (Coso Operating Company, 2024). Other programs (described next) indicate that additional geothermal development on DoD lands may be happening in the future.

DoD is pursuing a portfolio of projects through the Defense Innovation Unit, a government organization that accelerates adoption of commercial technologies for the military (Defense Innovation Unit, 2023; Sabin and Blake, 2023). The Defense Innovation Unit can fast-track many of the required steps typical of the federal acquisition regulations and is working to award contracts to potential geothermal developers to develop geothermal power on select military bases. Sixty-eight vendors replied to a Defense Innovation Unit notice inviting proposals for CH, EGS, or CLG projects for the Air Force, Army, and Navy (Sabin and Blake, 2023). Of these, the Defense Innovation Unit selected six entities to explore the potential of geothermal technologies in a total of seven DoD installations. The DoD locations (and awardees) include Joint Base San Antonio in Texas (Eavor), Fort Wainwright in Alaska (Teverra), Mountain Home Air Force Base in Idaho (Zanskar), Fort Irwin in California (Zanskar), Naval Air Station Fallon in Nevada (Fervo Energy), Naval Air Facility El Centro in California (GreenFire Energy), and Fort Bliss in Texas (Sage Geosystems) (Defense Innovation Unit, 2023; Sabin and Blake, 2023). Additionally, in August 2025, the DoD installations were expanded to include the Marine Corps Air Ground Combat Center Twenty-Nine Palms and the Sierra Army Depot, both in California (GreenFire Energy), the Naval Air Station Corpus Christi in Texas (Sage Geosystems), and the Army's White Sands Missile Range in New Mexico (Teverra) (Defense Innovation Unit, 2025).

In September 2024, the Department of the Air Force awarded Sage Geosystems a $1.9 million grant for a pilot demonstration of their next-generation technology at an off-site test well in Starr County, Texas (Bela, 2024). The pilot project is a precursor to a full-scale project at Ellington Field Joint Air Reserve Base in Houston, Texas (Bela, 2024).

Two additional DoD programs, the Strategic Environmental Research and Development Program and the Environmental Security Technology Certification Program support research and demonstration programs to improve DoD performance in various areas, including energy for its installations. One such program is a thermal microgrid project that integrates borehole thermal energy storage and heat pumps (Sabin and Blake, 2023).

3.5 Progress on EGS Commercialization

3.5.1 Technology Development

EGS designs are based on human-made rock fracture networks that connect multiple wells and enable subsurface fluid circulation and heat extraction. Fractures are induced by stimulation methods including hydro-shearing in systems with some naturally existing fractures, and hydraulic fracturing leading to the creation of planar fractures in systems that have little or no existing fractures. EGS is not a new concept. The first pilot test project was pioneered in the early 1970s by Los Alamos National Laboratory at Fenton Hill, New Mexico (Brown, 2009). Although the Fenton Hill project proved that hot dry rocks could be stimulated at depth, the project elucidated the uncertainty in fracture propagation and well productivity sustenance (Brown, 2009; Spivey, 2022). At least 65 other EGS pilot tests and demonstration projects have been implemented since Fenton Hill (Horne et al., 2025). Only a few of these projects were able to achieve more than a few MWe installed nameplate capacity. Common challenges encountered were well integrity loss, overpressure, lack of well connectivity, water loss, induced seismicity control, etc. (Pollack et al., 2020; Breede et al., 2013). To address some of these issues, DOE initiated the EGS Collab project and subsequently, the Utah FORGE was created.

The EGS Collab project implemented three distinct experiments at the Sanford Underground Research Facility in Lead, South Dakota. Subhorizontal boreholes were drilled at the depth of existing drifts (i.e., horizontal or subhorizontal tunnels) to experiment with two stimulation techniques, hydraulic fracturing and shear stimulation (or hydro-shearing) in crystalline rocks at 1.5-km and 1.25-km depths, respectively (Kneafsey et al., 2024). Through a long-duration flow test, fracture connectivity and flow between injection and production wells were confirmed in the rock that was stimulated by hydraulic fracturing (Kneafsey et al., 2024). The project did not record significant fracture opening and propagation, and consequently, no improved permeability, after shear stimulation. The EGS Collab team recommended that for commercial-scale projects, hydro-shearing may need to be accompanied by hydraulic stimulation or other methods such as chemical stimulation and electro-fracturing for optimal reservoir creation (Kneafsey et al., 2024).

DOE's FORGE site in Milford, Utah, which is an underground laboratory for developing, testing, and de-risking innovative tools and stimulation techniques for developing EGS reservoirs, commenced in 2017 and has been largely successful at showing a replicable process for developing EGS reservoirs. The project has reported significant feats both in drilling, completion, and stimulation in high-temperature crystalline rock. A total of seven wells have been drilled within the project lease area, including a pilot well, four monitoring wells, a 10,987-ft long (8,559-ft vertical depth) injection well (Well 16A(78)-32) and a 10,947-ft long (8,262-ft vertical depth) production well (Well 16B(78)-32). Both injection and production wells are deviated wells, characterized by a vertical section and a lateral section, while all others are strictly vertical wells. Well 16B(78)-32, the latest well, was drilled and completed between April and June 2023, and remarkable improvements in drilling performance were achieved including reduction in on-bottom drilling hours (110 hours compared to 310 hours for Well 16A (78)-32 drilled in 2020) (Dupriest and Noynaert, 2024). Multistage stimulation by hydraulic fracturing in both injection and production wells were completed in March 2024. In August 2024, a long-duration flow test was implemented by continuously circulating water through the Well 16A (78)-32, into the subsurface fractures, and out of the Well 16B(78)-32 for nearly a month. The stable production of injected fluid at a temperature of 370°F (188°C) with a minimum of 90% injected fluid recovery confirmed a commercially viable EGS reservoir (Utah FORGE, 2024). A network of permanent seismic stations and nodal geophones (vibration sensors) monitored the area during well stimulations and the long-duration flow test, recording any events of induced seismicity. The maximum induced seismicity was magnitude 1.9, lower than the threshold for felt seismicity (Niemz et al., 2025).

Before the FORGE flow test, Fervo recorded in May 2023 the first commercial-scale EGS reservoir development in the United States at the Blue Mountain Geothermal Field in Nevada (Norbeck and Latimer, 2023). Specifically, Fervo's injection-production well doublet was able to sustain a maximum production of 60 liters per second [l/s] for up to 37 days with a production temperature of 185°C. The well doublet is tied to the existing surface plant at the Blue Mountain Field operated by NV Energy and provides an additional 3.5 MWe to the current capacity. By 2028, Fervo plans to build and operate the world's first 400-MWe (recently scaled up to 500 MWe) EGS geothermal plant at their Cape Station site near the Utah FORGE project site in Beaver County, Utah (Fervo Energy, 2024a). The first 70 MWe is anticipated to come online by 2026. Ongoing field development at the site has recorded industry leading drilling times (16 days from spud to total depth) (Fervo Energy, 2025) and costs (~$350 per foot) as well as a 13% in-project drilling learning rate (corresponding to 33%[25] global drilling rate) (El-Sadi et al., 2024). Fervo has also recorded maximum production levels of 120 kg/s from Cape Station compared to 63 kg/s in Project Red, suggesting that EGS can achieve comparable well flow rates as conventional hydrothermal systems (Norbeck et al., 2024; Norbeck and Latimer, 2023).

Sage Geosystems is developing an EGS technology called Geopressured Geothermal Systems. This technology creates pressurized open fractures in a low permeability formation by injecting fluids at pressures above the minimum principal stresses of the fractures while ensuring that pressures are not high enough to induce uncontrolled fracture propagation, which could lead to significant risks such as induced seismicity and water losses (Rivas et al., 2024). The pressurized geofluid is then produced into a high-pressure binary plant at the surface to generate power. Between 2021 and 2022, Sage pilot tested the Geopressured Geothermal Systems technology in an existing gas exploration well in Starr County, Texas. Sage created a vertical fracture from a cased interval of the well into the adjoining low-permeability sedimentary formation (Simpkins et al., 2023). The company is currently embarking on a field demonstration at a site in Starr County, Texas and was scheduled to drill a test well in 2025 (Sage Geosystems, 2025).

3.5.2 Technology Commercialization

EGS commercialization has been spurred by both government and private sector funding. The GTO announced the *Enhanced Geothermal Shot™* in 2022, a DOE-wide effort to reduce the cost of EGS by 90% to $45 per megawatt-hour by 2035 (Augustine et al., 2023a). In February 2023, DOE announced the EGS Pilot Demonstrations funding opportunity to stimulate EGS commercial development in both the western and eastern United States with the goal of accelerating geothermal power generating capacity to 90 GWe by 2050 (GTO, 2024a). Targeted resource developments include brownfield, greenfield, and superhot EGS. In February 2024, DOE announced the first round selectees, including Chevron New Energies, Fervo Energy, and Mazama Energy, with a total of $60 million in funding to demonstrate commercial-scale EGS in unique locations and geologies (GTO 2024a). The second round of applications closed on September 24, 2024, and selections are pending (GTO, 2024a).

Based on public data collated for this report, about $990 million in private capital was raised by major EGS developers between 2021 and June 2025 (Figure 26). Specifically, Fervo Energy raised $973 million, including $642 million in equity and $331 million in debt financing (Fervo Energy, 2024a, 2024b, 2024c, 2025). Sage Geosystems raised $17 million in equity within the same period (Business Wire, 2024b). The significant (~33%) debt percentage of the total investments reveals the positive impact of ongoing EGS demonstration and commercial projects on technology de-risking. From a global future perspective, the International Energy Agency

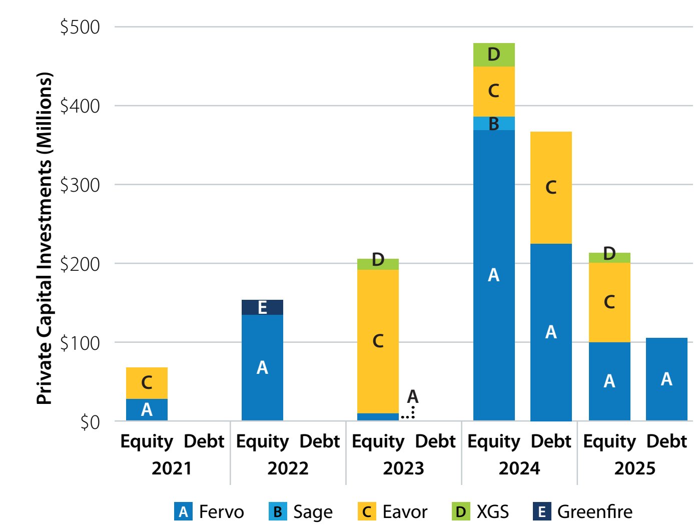

Figure 26. Private capital investments in next-generation geothermal developers between 2021 and June 2025. *Sources: Fervo Energy (2024a, 2024b, 2024c, 2025), Business Wire (2024a; 2024b; 2025a), Eavor Technologies (2024a; 2024b), and Pitchbook (2025).*

[25] Updated from 35% in El-Sadi et al. (2024) to 33% based on presentation by Jack Norbeck at the 2025 Stanford Geothermal Workshop.

estimates that $1 trillion is projected to be invested in next-generation geothermal by 2035, reaching $2.5 trillion by 2050 (IEA 2024).

3.6 Progress on Advanced (Closed-Loop) Geothermal Systems

3.6.1 Technology Development

Closed-loop geothermal (CLG) technologies, sometimes known as advanced geothermal systems, take advantage of the thermal gradient that develops within a wellbore as a result of the external thermal gradient in the formations it traverses. Generally, closed-loop wells exchange thermal energy from hot rocks mostly by conductive heat transfer from the hot formation to the cooler well. Therefore, convective fluid flow is limited to the wellbore and the rate of conductive heat exchange is dependent on the wellbore surface area. Although closed-loop concepts for geothermal energy extraction have been around for almost a century (Hodgson, 1927), they have recently gained attention due to the rising demand for more ubiquitous geothermal energy supply, especially beyond traditional geothermal (hydrothermal resource-rich) regions like the western United States. There is currently no resource potential assessment for CLG. However, closed-loop systems can operate in subsurface environments favorable for hydrothermal, EGS, and petrothermal (hot dry rock) type resources. CLG resources can also be extended to sedimentary basins that have suitable temperature gradients for economic thermal energy extraction.

Because CLG systems do not inherently require a flowing hydrothermal or an engineered thermal reservoir, they could benefit from savings on significant expenses on extensive subsurface exploration and resource confirmation. In addition, operational monitoring of the subsurface is restricted only to the wellbore and the surrounding formation without the primary need for intensive reservoir management. Using closed loops also reduces the incidences of scaling and the ensuing pressure drop caused by dynamic changes in the geochemistry of the fluid in the wellbore. However, production temperatures of CLG follow a specific temporal behavior—a transient period, early in time, with a sharp decline in temperature, followed by a slower decline in temperature. They also require extensive drilling due to the critical need for a large surface area for sufficient heat transfer between the rock and the fluid in the wellbore.

Three main CLG designs have been posited by developers, including (a) a vertical co-axial or "pipe-in-pipe" system consisting of the well and a concentric insulated tubing, (b) a co-axial system with a lateral extension, and (c) a U-loop system with single or multiple laterals (Beckers et al., 2022; Brown et al., 2023). Water and supercritical carbon dioxide (sCO_2) have been proposed as suitable heat transfer (i.e., working) fluids[26] (Beckers et al., 2022). The Closed-Loop Geothermal Working Group—a DOE-funded consortium of several national labs and academic institutions—investigated a variety of CLG systems and determined that these temperature characteristics are common across designs and stem from conduction through reservoir rock as the dominant heat transfer mechanism in CLG systems. The sharp early decline in production temperature has significant implications to the CLG economic viability (Beckers et al., 2023; Bernat et al., 2025; White et al., 2024).

The CLG market has grown from a niche market to one with multiple players, each with their innovative proprietary technologies. Active players include, but are not limited to, Eavor Technologies, GreenFire Energy, and XGS Energy. These companies are at various stages of technology development, and their technologies are briefly described next.

Eavor has three proprietary designs, the Eavor-Lite, Eavor-Loop 1.0, and Eavor-Loop 2.0 (a slight modification of the Eavor-Loop with an angular lateral). Eavor-Lite, Eavor's first design iteration, is a U-loop system installed in Sylvan Lake, Alberta, Canada, that comprises two 2.4-km deep vertical wells connected by two 1.7-km open hole horizontal laterals. The thermal energy output from the formation initially at 78°C (stabilized to 50°C outlet temperature) over four years of operation (2019–2023) was about 20 GWhth (Zatonski et al., 2023). The Eavor-Loop 2.0 demonstration project, called Eavor-Deep, was implemented in New Mexico between August and December 2022. In this project, Eavor drilled a two-leg multilateral well (i.e., a single vertical well with a sidetrack) to a true vertical depth of 18,000 ft and rock temperature of ~250°C. By replicating the first half of their Eavor-Loop design, Eavor demonstrated the technical feasibility of high-temperature hard rock drilling of a multilateral well (Brown et al., 2023). In 2023, Eavor commenced a commercial Eavor-Loop project in Geretsried, Germany. The system will consist of four horizontal loops (Eavor-Loop 1.0) at a 4.5-km depth with a planned power output of 8.2 MWe (64 MWth) (Koning, 2023).

GreenFire Energy has developed its GreenLoop technology for CLG in greenfields, legacy geothermal wells, and high-

[26] The Eavor-Loop has its own proprietary working fluid (https://www.eavor.com/technology/).

temperature oil and gas wells. The GreenLoop is primarily a co-axial closed-loop system that can serve as a downhole heat exchanger in existing wells. This takes advantage of the convection (could be free or forced) of steam or multiphase fluid from the hot reservoir to the original well, and the heat conduction between the well and the downhole heat exchanger that uses either water or sCO_2 as a working fluid (Scherer et al., 2020). GreenFire has tested the GreenLoop in an existing geothermal well in the Coso Geothermal Field in California. The subsurface setup includes a vertical co-axial loop (1,083-ft vacuum insulated tubing within a plugged liner) inserted into the hot well with a bottomhole temperature of 200°C. The test demonstrated that the system could generate 1.2 MWe of gross power with water as a working fluid (Scherer et al., 2020).

XGS Energy has developed its Thermal Reach Enhancement technology that aims to improve heat conduction between the hot rock and the working fluid in a closed-loop system. This enhancement is based on a proprietary liquid slurry that is introduced into and fills up the open hole perforations and natural fractures within the near-wellbore region (1–10 m) of the hot rock. According to XGS, this slurry then cures and solidifies at reservoir conditions, creating a highly conductive (up to 50 times the conductivity of the rock) buffer between the rock and the working fluid in the well. Using this technology, XGS estimates thermal outputs of 3-10 MWth per well (Jacobs, 2024).

3.6.2 Technology Commercialization

As a nascent geothermal technology, CLG systems are characterized by a wide range of costs that depend on design, depth, temperature, and application (heating or electricity). NLR led two techno-economic assessments estimating costs for co-axial, U-loop, and the Eavor-Loop systems (Beckers et al., 2022, Beckers and Johnston, 2022).

In the first study, NLR assessed multiple configurations of co-axial (with and without a lateral section) and U-loop (with 1, 2, 5, and 13 laterals) well designs with water and sCO_2, respectively, as working fluids at multiple temperatures between 100°C and 500°C (Beckers et al., 2022). Their results showed that the levelized cost of heat (LCOH) could range from ~$20 to $110/MWh (~$6 to $32/million British thermal units [MMBtu]) for co-axial and ~$10 to $70/MWh (~$3 to $20/MMBtu) for U-loop. For power generation applications, the LCOE ranged from $83/MWh (U-loop with two laterals at 500°C, $200/m drilling cost) to $2,200/MWh (co-axial with no lateral at 200°C, $1,000/m drilling cost). Additionally, the study suggested that CLG economics is dominated by the cost of deviated well drilling in hard rock. Specifically, for a U-loop system with two laterals, Beckers et al. (2022) found that by reducing drilling costs from $1,000/m to $200/m LCOE declined by 28% (Beckers et al., 2022).

In the second study, NLR simulated the Eavor-Loop 2.0 design consisting of two vertical (injection and production) wells and 12 looped laterals (75-m spacing) targeting a 7.5-km deep formation. NLR determined that to achieve an LCOE of < $70/MWh (as with existing geothermal PPA pricing), a geothermal gradient of 60°C/km, discount rate below 9%, and lateral drilling cost below $400/m is required.[27] For heating applications, NLR derived competitive LCOH values between $4.32 and $29.52/MWh[28] for a lower geothermal gradient (30°C/km) and lateral drilling cost of $600/m (Beckers and Johnston, 2022). Therefore, closed-loop systems may already be cost-competitive for heating applications.

The Closed Loop Geothermal Working Group funded by DOE is a collaboration across four national laboratories, including NLR, Pacific Northwest National Laboratory, Oak Ridge National Laboratory, and Sandia National Laboratories, and experts across academia and industry. The group has developed numerical models and analytical tools to evaluate the techno-economic feasibility of CLG systems (White et al., 2024). The culmination of their work is the GeoCLUSTER tool, a cloud-based, techno-economic web simulator that enables geothermal stakeholders and the public to explore the techno-economic viability of CLG systems. The tool simulates both co-axial and single-lateral U-Loop designs with water or sCO_2 as heat transfer fluids in the well (Bernat et al., 2025).

The potential of commercial-scale CLG in the United States largely depends on the learning curve of drilling multilateral wells in deep hard rocks. Lower LCOH and LCOE may be obtained by optimizing well designs to increase the surface area of contact with the rock and the residence time of the working fluid in the vertical wellbore and the lateral network (within the techno-economic limit of the number, length, and spacing of laterals). Costs might also be reduced by repurposing existing geothermal and oil and gas wells. Scaling CLG requires investments that enable multiple pilots in various geological settings, depths, and temperatures. Eavor received about $529 million in investments between 2021 and June 2025 (Figure 26). This includes $387 million in equity through multiple investor funding rounds and $142 million

[27] Eavor is targeting an LCOE of $60/MW for commercial-scale Eavor-Loop deployment (https://www.eavor.com/eavor-deep/). XGS is targeting $35/MWh (using existing wellbores) and $50/MWh with new wells (https://jpt.spe.org/hot-rock-slurry-developer-of-emerging-geothermal-tech-readies-for-field-tests).

[28] Annual U.S. natural gas residential price between 2018 and 2023 ranged from $35.82/MWh to $51.96/MWh (https://www.eia.gov/dnav/ng/NG_PRI_SUM_A_EPG0_PRS_DMCF_M.htm)

(€130 million) in debt financing from a group of international financial entities (Eavor Technologies, 2024a; 2024b). Similarly, XGS Energy and Greenfire Energy raised $56.7 million and $19 million, respectively, in equity investments between 2022 and March 2025 (Business Wire, 2024a, 2025a; Pitchbook, 2025). Despite growing interest and investment in CLG, a first-of-a-kind commercial CLG power plant has not been developed in the United States as of June 2025.

3.7 Geothermal Power and Data Centers

Electricity demand is estimated to increase by as much as 8.2% by 2029, driven in part by exponential increases in data center loads (Wilson et al., 2024; Shehabi et al., 2024). Lawrence Berkeley National Laboratory's 2024 *United States Data Center Energy Usage Report* estimates that data center load growth has tripled over the past decade and is projected to double or triple by 2028. Further, the report explains that data center electricity consumption is expected to rise from 4.4% in 2023 to approximately 6.7%-12% of total U.S. electricity by 2028 (Shehabi et al., 2024). The surge in data center power demand could strain the electricity grid, but geothermal energy has the potential to alleviate some of this demand with reliable, affordable, and flexible power.

Based on NLR analysis, next-generation geothermal could potentially provide more than 85 GWe of electricity-generating capacity by 2050 (Augustine, 2023b). While much of this capacity would be deployed in western U.S. states, multiple gigawatts could potentially be deployed in data center hubs in Texas, Virginia, Pennsylvania, and West Virginia by 2050 (Augustine, 2023b).

Several major tech companies have already turned to geothermal energy to power their operations reliably. Power supply agreements have been mostly for next-generation geothermal power. In 2024, Meta signed a PPA with Sage Geosystems for up to 150 MWe of geothermal power to support its U.S. data centers. Sage will use its proprietary geopressured geothermal system and expects the first phase to be online by 2027 (Meta, 2024). Similarly, Google expanded its partnership with Fervo Energy and NV Energy in 2024, securing 115 MWe of geothermal energy to supply its Nevada data centers (Hanley, 2024). In June 2025, XGS Energy and Meta signed an agreement for up to 150 MWe of next-generation geothermal power to support Meta's data center operations in New Mexico. The project deployment will be in two phases—an initial smaller phase, and a second, larger phase—both anticipated to deliver geothermal power to the New Mexico electric grid by 2030 (Business Wire, 2025b).

3.8 Geothermal Power Policy and Incentives Case Studies

STATES

29 states have incentive policies for geothermal power

This includes grants, rebates (e.g., cash rebate), tax incentives (e.g., property tax deduction or personal tax deduction), and other financial incentives[29] (e.g., reduced cost and/or free application fees for permit processing).

42 states and D.C., U.S. Virgin Islands, and Puerto Rico have existing regulatory policies for geothermal power

This includes but is not limited to energy and efficiency standards, net metering (or lack thereof), and interconnection standards.

FEDERAL DATA

Production Tax Credit

The Energy Production Tax was replaced by the Clean Electricity Production Credit, a technology-neutral credit as the Energy Production Tax credit was phased out at the end of 2024. This includes a base rate of 0.3 cents per kilowatt hour of electricity generated and up to 1.5 cents per kilowatt hour of electricity if factoring in domestic manufacturing bonuses, specific requirements for wage and apprenticeship programs, and/or for facilities located in areas designated as energy communities or on Tribal Land (26 USC § 45Y; Internal Revenue Service [IRS] 2024a). As of July 4, 2025, geothermal projects utilizing Section 45Y can have a later placed-in service deadline, effectively extending the PTC for geothermal facilities through 2036 (H.R.1 2025). The full credit is available for facilities that begin construction by the end of 2033 with a phased down credit beginning in 2034 and is repealed in 2036.

Investment Tax Credit

There is a 30% ITC for geothermal property constructed before January 1, 2025. There are additional potential bonuses for domestic manufacturing requirements or for projects located in energy communities (26 USC § 48E; IRS, 2025a). As of July 4, 2025, the ITC or Section 48E credit will also be available for facilities with construction commencing by the end of 2033; it will be phased down beginning in 2034 and repealed in 2036 (H.R. 1 2025).

Following the phaseout of the Investment Tax Credit in 2024, the § 48E technology-neutral tax credit replaces it. The technology-neutral credit includes a 30% ITC for the year it is placed in service, with additional potential bonuses for domestic manufacturing, and for projects in qualifying areas (26 USC § 48E; IRS, 2025a).

Geothermal powers parts of Reno, Nevada. *Photo from Getty 508353932*

[29] For the purposes of this analysis, the data collected do not include loans of any type.

INCENTIVE POLICIES

States with Existing Incentive Policies for Geothermal Power

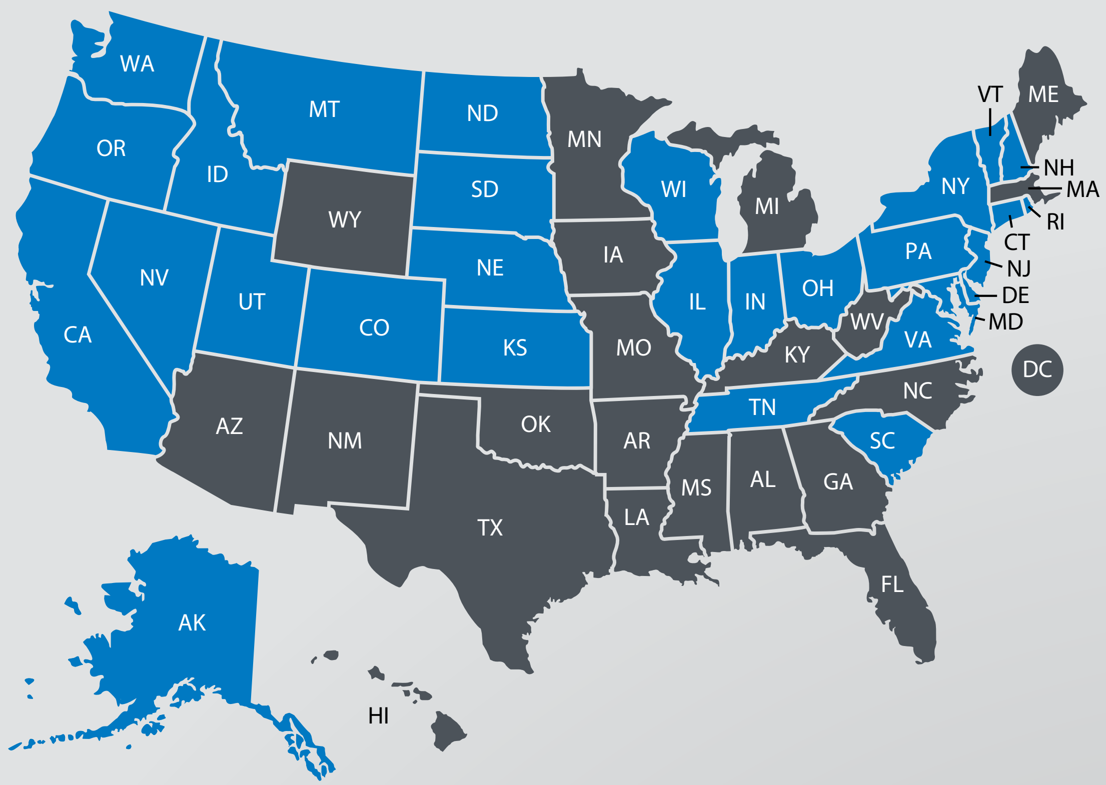

Figure 27. States with existing incentive policies for geothermal power as of December 2025

EXAMPLE 1

Colorado has a Geothermal Electricity Tax Credit Offering via competitive process for a total of $35 million in state ITC and up to $1 million in state premium tax credit per applicant per year (Colorado Energy Office, 2025).

EXAMPLE 2

Utah offers the Alternative Energy Development Incentive, a post-performance non-refundable tax credit for 75% of new state tax revenues (including state, corporate, sales, and withholding taxes) over the life of the project, or 20 years, whichever is less (Utah Code 79-6-501, 504 et seq.; Utah State Legislature, 2021).

EXAMPLE 3

Montana has a qualifying energy systems exemption which allows for a property tax exemption of up to $20,000 for single-family residential dwellings and up to $100,000 for multifamily residential dwellings or nonresidential structures for 10 years after installation of qualifying forms of energy production, including geothermal electricity (MCA § 15-6-224; Montana State Legislature, 2023).

RECENT PROJECT DEVELOPMENTS

The following are examples of projects that would have been eligible for the federal Investment Tax Credit (i.e., 30% credit for geothermal property constructed before January 1, 2025).

HELL'S KITCHEN POWER CO. 1
Developed by Controlled Thermal Resources (CTR)
Imperial County, California
Completed 2023

STAR PEAK
Developed by Open Mountain Energy
Pershing County, Nevada
Completed 2022

NORTH VALLEY
Developed by Ormat
Washoe, Lyon, Churchill, and Pershing Counties, Nevada
Completed 2023

REGULATORY POLICIES

States with Existing Regulatory Policies for Geothermal Power

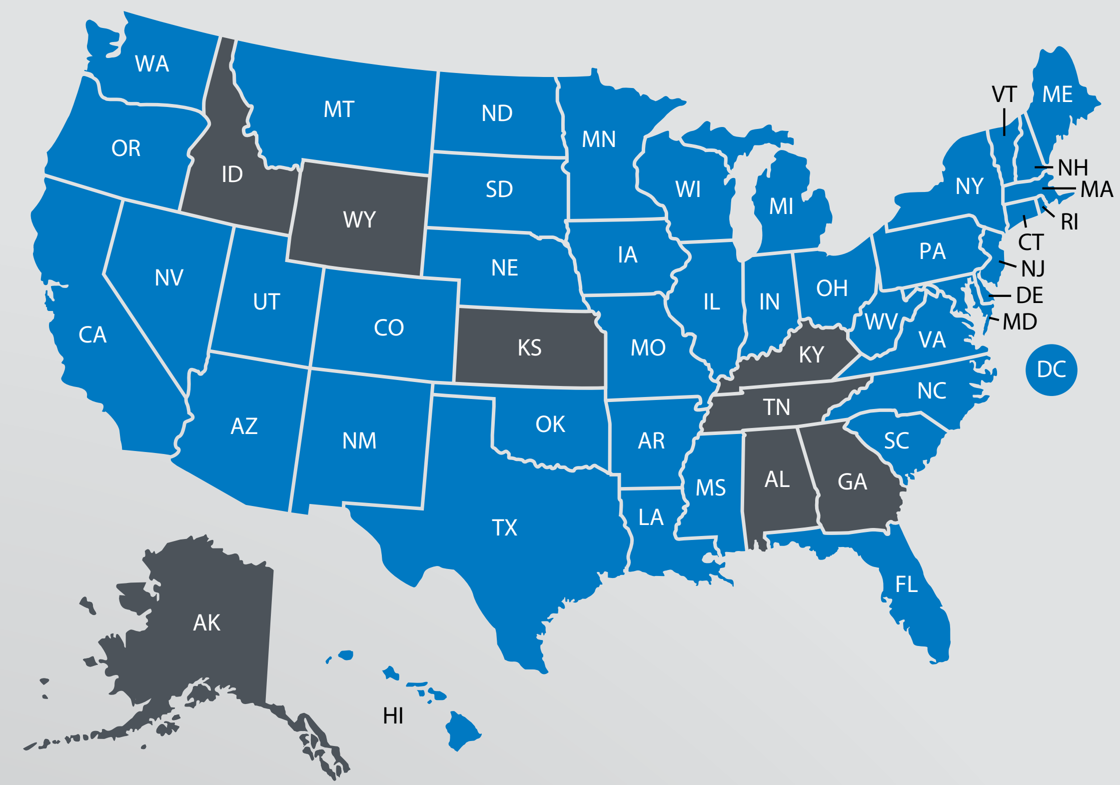

Figure 28. States with existing regulatory policies for geothermal power as of December 2025

EXAMPLE 1

Washington has a portfolio standard established through their Energy Independence Act (Washington State Legislature, 2022; 2024a). The Energy Independence Act requires utilities with more than 25,000 retail customers to comply. The Energy Independence Act's portfolio standard is based on the targets being a percentage of customer load, increasing over time, with a 15% standard by 2020. Additionally, the state has a regulatory requirement to have 100% of their electricity from specific qualifying resources by 2045 (Washington State Legislature, 2019). Both of these policies include geothermal power as an eligible energy resource.

EXAMPLE 2

Oklahoma's net metering policy defines the terms of an electric cooperative or utility purchasing electric power from a small power producer or co-generator of a system sized 300 kW or less (17 O.S. § 156 and OAC 165:40:9; see Oklahoma Supreme Court, 2024).

EXAMPLE 3

Oregon's Energy Standards for Public Buildings require public agencies to spend at least 1.5% of project costs on qualifying energy technology for buildings used by the public or buildings used by public employees (ORS 279C.527-528; Oregon State Legislature, 2025).

4. Geothermal Heating and Cooling Market Update

Geothermal energy can be used to provide both heating and cooling for residential and commercial buildings across multiple geographic and climatic regions. The market for geothermal heating and cooling in the United States is well established, with substantial installations at single buildings and at the district scale. These installations are primarily enabled by geothermal heat pumps that exchange thermal energy with the shallow subsurface to meet diurnal and seasonal thermal loads. This section takes a deep dive into the state of the geothermal heating and cooling market. Section 4.1 focuses on current geothermal heat pump technology and market trends in single-building installations. Section 4.2 discusses district-scale heating and cooling systems. This section also discusses cost trends (Section 4.3), future opportunities (Section 4.4), policy case studies (Section 4.5), and the additional value of geothermal heating and cooling to the grid (Section 4.6).

The geothermal system at the College of Southern Idaho in Twin Falls. *Photo from College of Southern Idaho*

4.1 Geothermal Heat Pumps

4.1.1 Technology Overview

Geothermal heat pumps (GHPs), also referred to as ground-source heat pumps, offer an efficient solution for heating and cooling residential and commercial buildings. GHPs transfer thermal energy with the earth at shallow depths—typically less than 200 m—which maintains a constant temperature year-round. In the summer the subsurface is cooler than the air above it and can act as a heat sink, and in winter the subsurface is warmer than aboveground air and can act as a heat source. This allows GHPs to deliver reliable and efficient heating during the winter and cooling in the summer, no matter the ambient weather conditions.

A typical GHP system consists of three main components: the ground loop, the heat pump (which can be classified as water-to-water or water-to-air), and the building distribution system (Figure 29). Ground loops, which are buried underground or submerged in water, serve as the primary interface between the system and the earth. These loops can be installed in several configurations, including horizontal, vertical, and pond/lake systems, depending on the building load, land availability, and environmental conditions. The heat pump unit inside the building consists of a condenser, evaporator, compressor, and expansion valve, and utilizes the thermal energy from the ground loop to provide heating or cooling. The building distribution system uses traditional ductwork or radiant heating systems to distribute the heating or cooling throughout the building.

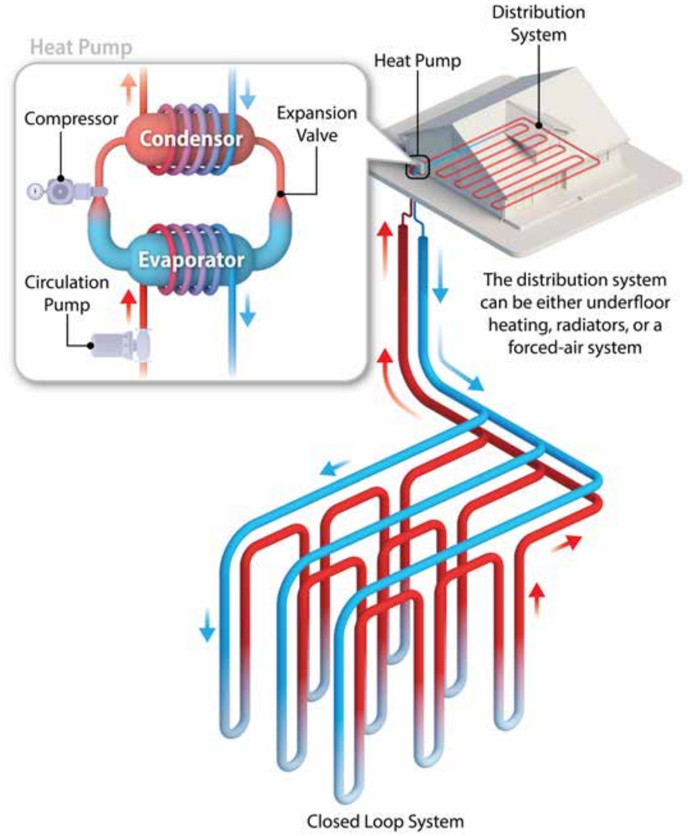

Figure 29. Major components of a closed-loop GHP system, including the ground loop, heat pump, and distribution system. *The system is operating to deliver heat into the building. Thermal energy is introduced into the heat pump unit using a circulation pump and is exchanged between the working fluid (usually a mixture of water and glycol) from the ground loop to the evaporator. After passing through the compressor, the pressurized hot vapor then exchanges thermal energy with the air via the condenser. The heated air then flows through the distribution system within the building for space heating, or underfloor heating may be used. Within the heat pump, the liquid refrigerant expands (i.e., depressurizes) and cools, as it flows through an expansion valve before returning to the evaporator to begin another cycle.*

GHPs are classified as either closed-loop, which are the traditional design discussed so far, or open-loop. Open-loop systems are less common, but they operate on a similar principle, drawing water directly from a nearby groundwater source, such as an aquifer or a surface pond or lake, to facilitate the heat exchange process. Once the water is used, it may be returned to the ground through a separate discharge well or discharged elsewhere. While open-loop systems can be efficient, their use is often limited by geographic, geological, and geochemical factors, water availability, and environmental regulations, making them less widespread than closed-loop systems.

Overall, GHP systems can be tailored to suit a variety of settings and site conditions, making them versatile and adaptable to different environments. Whether installed in a residential home, a commercial building, or even in large-scale industrial projects, GHPs can serve as efficient heating and cooling systems. The following subsections provide an overview of the existing market for GHPs.

4.1.2 Geothermal Heat Pump Market Overview

GHP systems have seen increased adoption across various sectors, including residential, commercial, and industrial applications. Residential use has been a major focus, as homeowners seek energy-efficient alternatives to traditional heating and cooling systems. In commercial and industrial settings, GHPs have been adopted for large-scale projects, such as office buildings, schools, and hospitals, where the long-term cost savings and reliability are particularly appealing. Regional trends in GHP adoption often align with factors such as local climate, policy support, and the economic feasibility of installation.

Recent advancements in GHP technology have significantly improved system performance and efficiency. Innovations in drilling techniques, like directional drilling, have increased the number of viable locations for GHPs by increasing access to the subsurface from a small surface footprint. Additionally, digital technologies like smart thermostats and internet-connected devices have enhanced GHP performance by optimizing energy use based on real-time data (Noye et al., 2022). These innovations have made GHP systems more accessible, cost-effective, and efficient, helping drive market growth.

4.1.2.1 Nationwide Use of Geothermal Heat Pumps

Existing GHP installations can be estimated using EIA's nationwide energy consumption data survey data—the Residential Energy Consumption Survey (RECS) (EIA, 2023b) and Commercial Buildings Energy Consumption Survey (CBECS) (EIA, 2023b). State-level end-use energy consumption data are available in the RECS data (e.g., natural gas consumption for space heating in a state). CBECS provides end-use energy consumption data at census division[30] level where multiple states are grouped into nine divisions. However, these two nationwide surveys have limited representativeness, and additional data

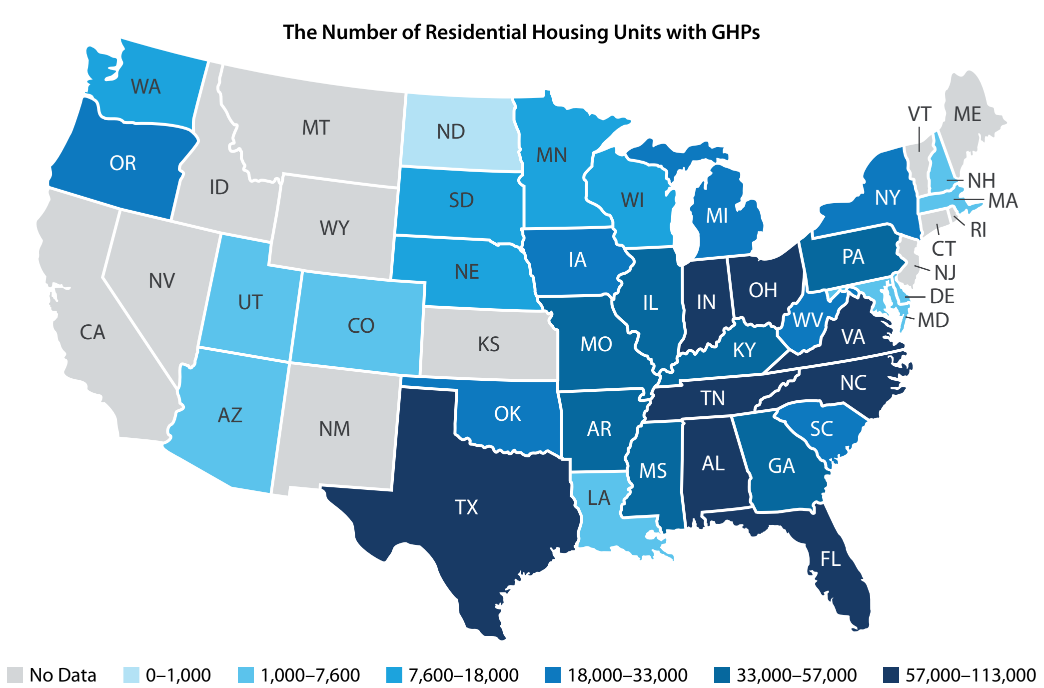

Figure 30. Estimated number of residential buildings with GHPs using EIA 2020 RECS microdata version 7. *EIA 2020 RECS includes the number of housing units with GHPs at state level. No data were available in 2020 RECS for GHP usages in Alaska, California, Connecticut, District of Columbia, Idaho, Kansas, Maine, Montana, Nevada, New Jersey, New Mexico, Rhode Island, Vermont, and Wyoming.*

[30] The nine U.S. census divisions are Pacific, Mountain, West North Central, East North Central, New England, Middle Atlantic, West South Central, East South Central, and South Atlantic. The census division maps can be found in the 2018 Commercial Buildings Energy Consumption Survey - Building Characteristics Highlights (https://www.eia.gov/consumption/commercial/data/2018/pdf/CBECS_2018_Building_Characteristics_Flipbook.pdf).

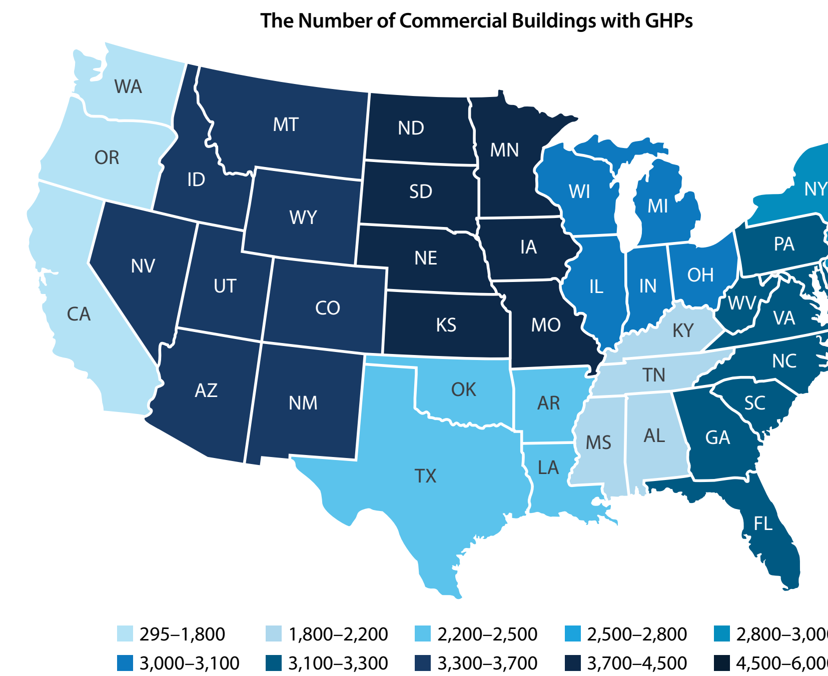

Figure 31. Estimated number of commercial buildings with GHP using the EIA's 2018 CBECS data. *Note that CBECS data is recorded at census division level. The survey collected data for 6,436 buildings, representing 5.9 million (i.e., 0.11% of) commercial buildings in the United States.*

collection or case studies may be required for specific cases. For example, Figure 30 does not clearly illustrate the total number of GHP installations in California in the RECS database due to the limited representation of California's housing units (less than 0.1% sample representativeness). Similarly, in the 2018 CBECS microdata, only 6,436 survey responses are used to represent an estimated 5.9 million commercial buildings in the United States.

Figure 30 and Figure 31 show estimated nationwide GHP deployments in residential and commercial sectors based on the EIA's 2020 RECS microdata version 7 (EIA, 2023a) and 2018 CBECS microdata (EIA, 2021). Overall, 1.04% of the responses in RECS and 1.1% of the responses in CBECS reported GHP usage for heating and cooling. Based on the two nationwide energy consumption surveys, the total number of residential and commercial buildings with GHPs was estimated at 1.27 million and 27,300, respectively. In the residential sector, Florida, Tennessee, and North Carolina have the highest number of housing units with GHPs, in that order. Note that this result may reflect representativeness limitations in RECS and CBECS data as discussed.

In the commercial sector, the West North Central region is estimated to have the highest number of commercial buildings with GHPs, followed by the Mountain and South Atlantic regions. In total, GHPs supply heating and/or cooling to 1.01% of the total area of commercial buildings in the United States, equating 977 million square feet (ft^2) (EIA, 2021).

Residential Annual Sales

Another way to assess the GHP market is to look at annual shipment and sales data. Since 2010, the Environmental Protection Agency has collected annual shipment data for ENERGY STAR® qualified products, including GHPs. Although these data are limited to residential ENERGY STAR certified appliances and do not represent the entire GHP market, they still offer valuable insights into the industry's overall health. Figure 32 shows annual shipments of ENERGY STAR GHP units from 2010 to 2023, categorized by system type. The highest number of shipments occurred between 2010

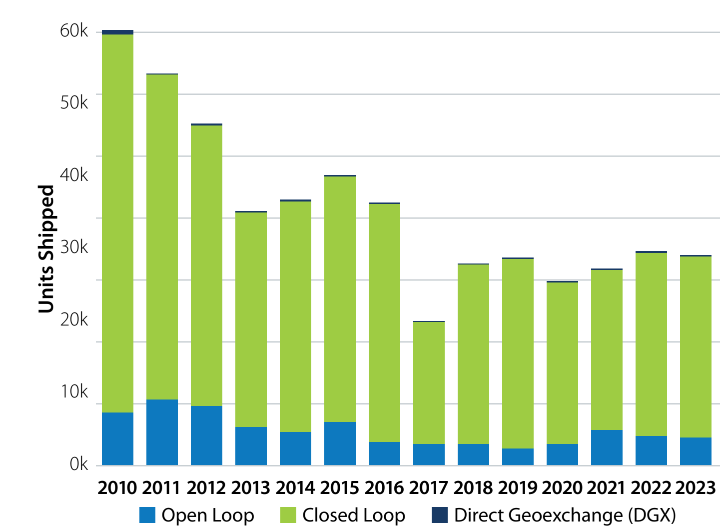

Figure 32. Annual ENERGY STAR residential GHP shipments. *Data sourced from the Environmental Protection Agency via email correspondence.*

and 2012, followed by a sharp decline. This drop could be attributed to factors such as shifts in policy support, market saturation, or economic challenges that emerged after the initial surge in adoption. The number of annual residential GHP shipments has remained relatively stable at approximately 30,000 since 2018.

4.2 Geothermal District Heating and Cooling

4.2.1 Technology Overview

In addition to using geothermal energy to heat and cool individual buildings, geothermal can also be used to space condition a group of buildings, known as a district. There are two main types of geothermal district heating and cooling systems: geothermal direct use (GDU) and Thermal Energy Networks (TENs).

GDU refers to the "direct" use of geothermal energy for heating (e.g., space conditioning in buildings) and other applications without converting it into electricity. GDU relies on moderate to low-temperature geothermal resources, often below 150°C. Boise, Idaho, commissioned the first GDU system for heating in the 1890s. The Boise system is still operating today and supplies heat and hot water to 88 buildings in downtown Boise (City of Boise, 2024). Traditional GDU systems like Boise's use thermal energy directly from a deep (usually greater than 300 m or 1,000 ft) geothermal resource.

In addition to district heating, GDU can be applied in greenhouse heating, aquaculture pond heating, and various industrial processes. GDU systems involve geothermal wells that are drilled to access subsurface reservoirs at elevated temperatures, along with a network of piping systems to transport the produced fluid to its end-use destination. GDU systems provide consistent heat with high efficiency because they do not experience the losses typically associated with converting heat into electricity. Figure 33 shows a GDU district heating system.

An alternate district geothermal technology is a TEN. This type of district-scale system exchanges heat with the ground via shallow geothermal wells, rather than utilizing hot water directly (Buffa et al., 2019; Lund et al., 2021), which allows for both heating and cooling in the networked system. Section 2.2.2 provides a more nuanced description of the different "generations" of district system technology (e.g., 4G, 5G). In this report, the term TEN describes all GHP-based 5G district heating and cooling systems with single or multiple loops. Figure 34 illustrates a TEN that interconnects multiple building types with decentralized heat pumps and thermal energy sources/sinks, including geothermal boreholes, wastewater, sewer water, and data center waste heat.

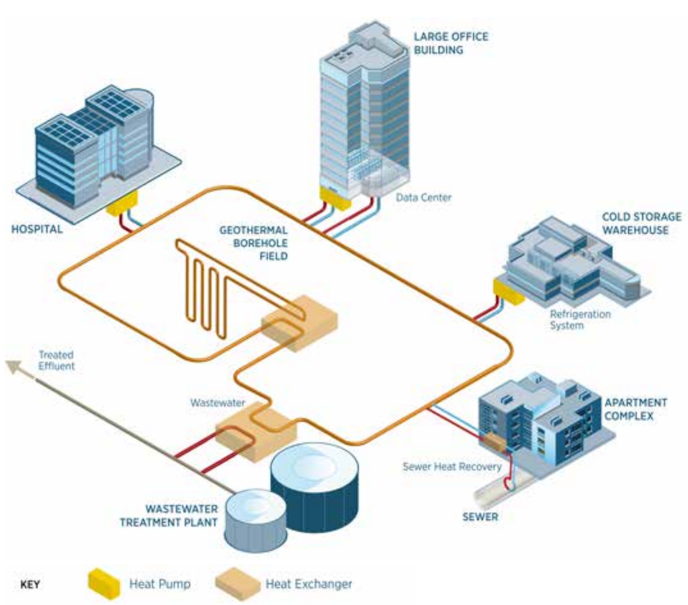

Figure 33. An illustration of a geothermal direct use district heating system. *The GDU district heating system consists of a deep geothermal well field with a production well (and an injection well) that directly supplies (and receives) thermal energy to (and from) a central plant fitted with heat exchangers and circulation pumps that distribute hot water to and from connected buildings, including a hospital, an apartment building, an office building, and a greenhouse. Figure from Simpson et al. (2024); graphic by Marjorie Schott, National Laboratory of the Rockies.*

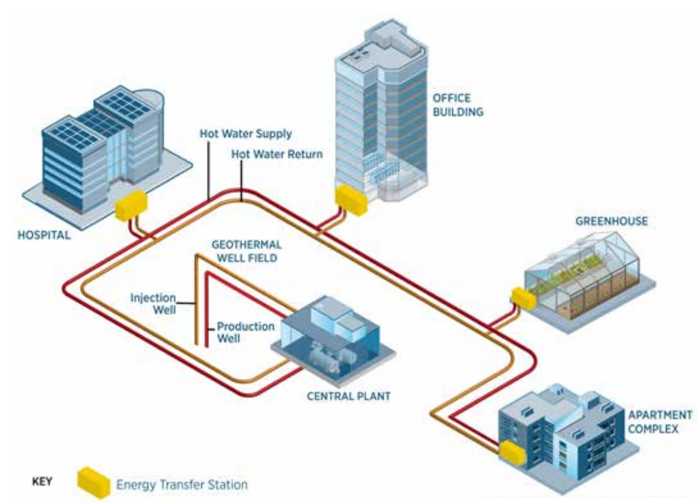

Figure 34. An illustration of a TEN (5G heating and cooling system). *The TEN consists of decentralized heat pumps in buildings connected to an ambient temperature loop that exchanges thermal energy between multiple sources and sinks, including geothermal boreholes (and borehole energy storage), waste heat from wastewater treatment, sewer water, and a data center. Graphic by Marjorie Schott, National Laboratory of the Rockies.*

4.2.2 Geothermal Direct Use Market Overview

GDU has a long history in the United States, dating back to Native Americans who used the heat from naturally occurring hot springs. District heating expanded from the late 19th century and into the 20th century, particularly in the western United States where abundant geothermal resources exist. The majority of the 24 active GDU district heating systems in the United States were installed in the 1980s (Robins et al., 2021). Since 2000 there have been only four new GDU district heating system installations in the United States, including the Modoc Joint Unified School District installed in 2017 (Robins et al., 2021). Cornell University is also investigating a GDU district heating system and drilled and completed an exploratory well in 2022. The Cornell project titled "Earth Source Heat" was co-funded by a DOE grant of $7.2 million (Cornell University, 2024).

Looking more broadly at GDU end uses in addition to district heating, Figure 35 shows the number and distribution of GDU installations in the United States as of October 2024. As shown in the figure, GDU for resorts and pools accounts for the largest market share with 281 installations. This is followed by space heating[31] (77), aquaculture (47) greenhouse (37), and district heating (25) applications. Resorts and pools dominate the GDU market because they are the foremost historical GDU applications and do not require significant cost investments and dedicated drilling like district heating systems. California currently has the most GDU installations in the United States with 89 installations, 62 of which are for resorts and pools. Idaho has the second highest number of GDU installations and dominates the geothermal district heating market.

A promising advancement for the future of GDU systems is the development of EGS, which can access geothermal heat in areas with limited naturally occurring hydrothermal resources. Although EGS has been developed mainly for power generation, it can also be pursued for direct-use heating systems. An example is the Rittershoffen Geothermal Heat Plant in France which produces up to 27.4 MWth from an EGS resource for industrial use (Ravier, 2020).

4.2.3 TENs Market Overview

State-of-the-art geothermal district heating and cooling systems (i.e., TENs) are typically enabled by heat pump technologies and deployed in housing complexes, campuses, and municipalities. Considering a broad definition of TENs, Figure 36 shows the distribution of GHP-based district heating and cooling installations in the United States

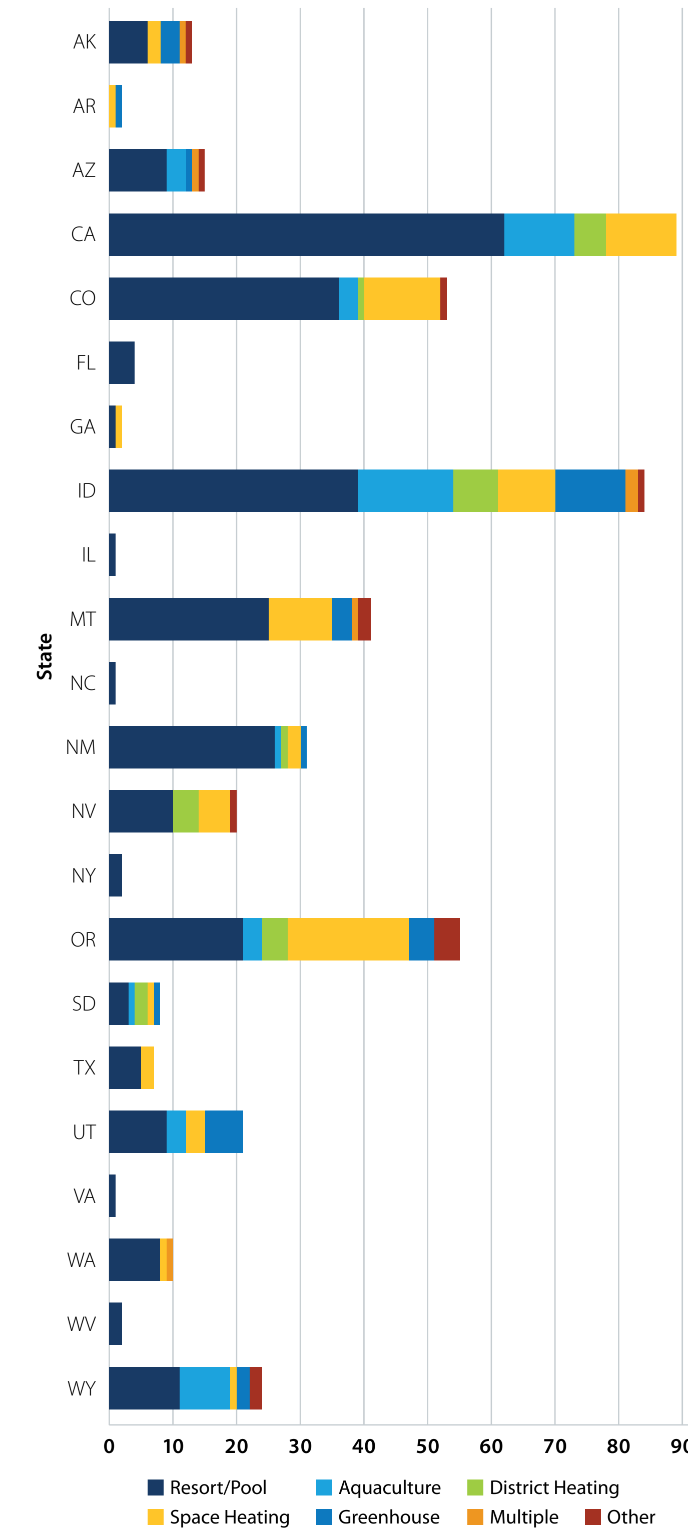

Figure 35. Geothermal Direct Use distribution within the United States (as of October 2024). *Data originally compiled by the Geo-Heat Center, Oregon Institute of Technology presented in Snyder et al. (2017), updated in Mattson and Neupane (2017), and Robins et al. (2021), and supplemented by information from news articles, publications, and direct data collation from interviews and email correspondences with project owners and operators. They include resorts/pools (281), aquaculture (47), district heating (25), space heating (77), and greenhouses (37). The seven "Multiple" systems combine two of the prelisted uses. "Other" uses include dehydration, snow melting, irrigation, and gardening.*

[31] Space heating refers to providing thermal energy to warm up a room or all rooms in a single building.

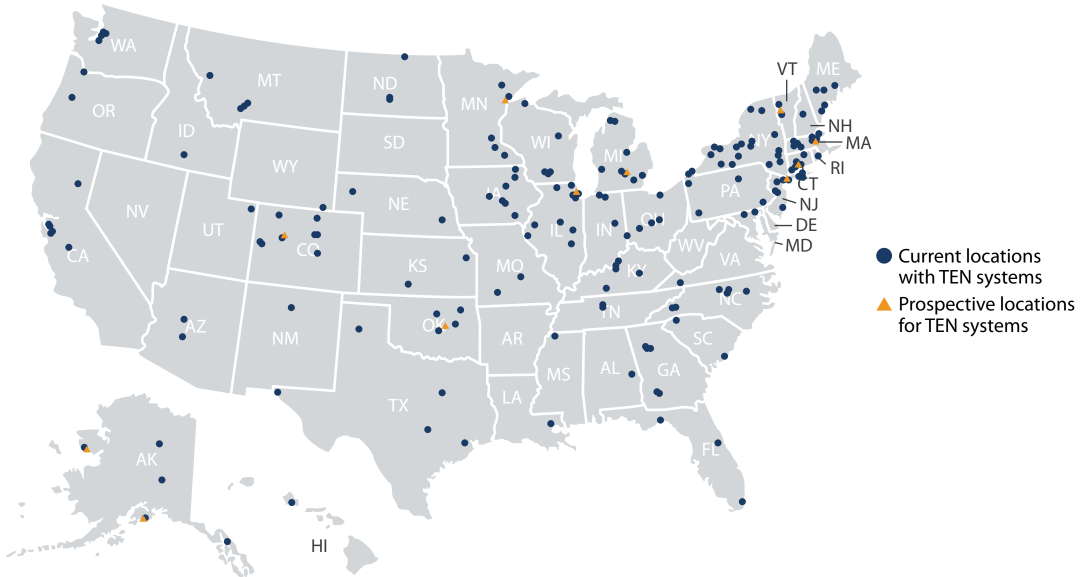

Figure 36. Existing GHP-based district heating and cooling installations on campuses across the United States. *It is important to highlight that this map extends the definition of TENs to accommodate single large buildings and GHP installations in more than two buildings. Based on data compiled from Cross et al. (2011) and multiple public sources, including news clippings, press releases, developer and college websites.*

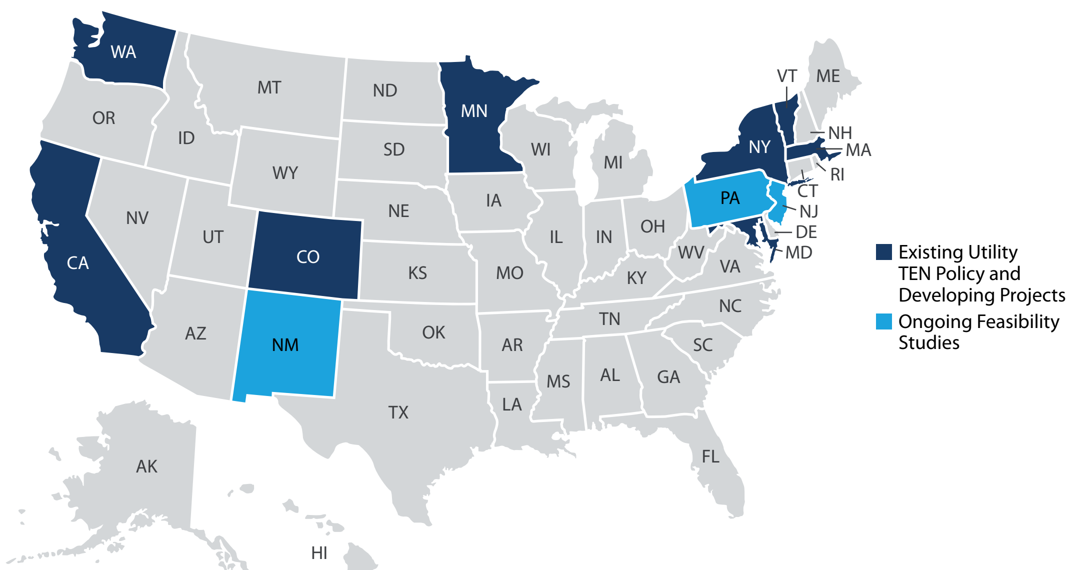

Figure 37. State policy activity on TENs as of October 2024. *States with existing policies that mandate utilities to consider TENs in their expansion plans (dark blue). New Mexico, Pennsylvania, and New Jersey (light blue) are currently implementing feasibility studies on the socio-economics of TENs. Data from the BDC (2024)*

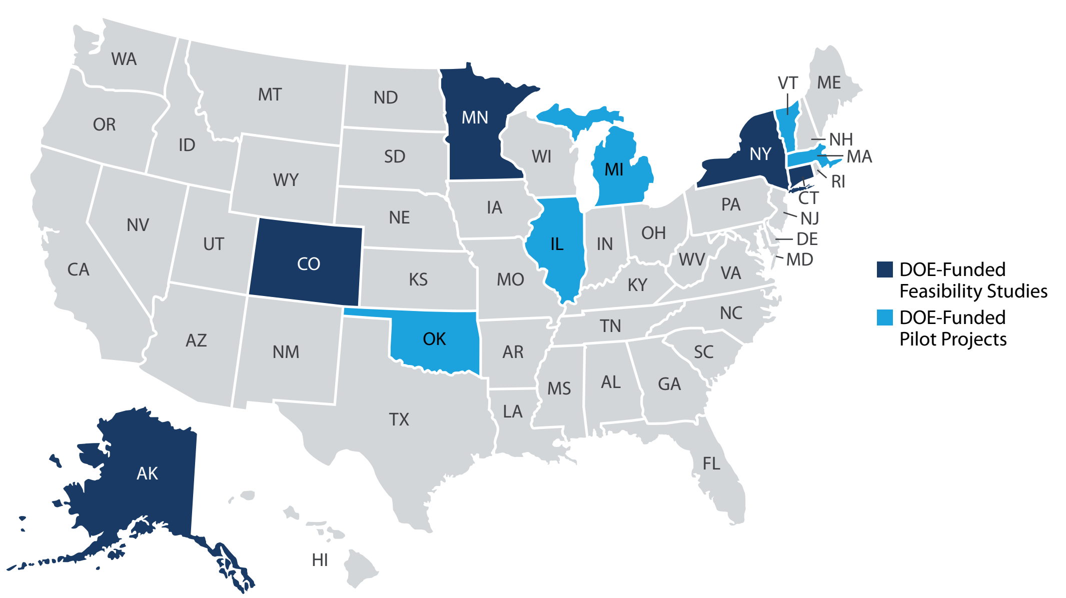

Figure 38. The DOE-funded District-Scale Geothermal Energy Pilots initiative includes 11 communities in 10 states. Five of these communities (in states highlighted in light blue) have been shortlisted for pilot project implementation after an initial feasibility study. *Map data from GTO (2025b)*

including campus TENs (colleges and military installations), utility-owned TEN pilots, and GHPs installed in at least two buildings (DOE, 2025). A primary driver for the proliferation of TENs is the desire for reliable systems that can achieve long-term energy efficiency goals (DOE, 2025). For military campuses a primary driver is the requirement for energy independence, reliability, and resilience for mission-critical operations (DOE, 2025).

TEN pilot projects have been started by energy utilities in California, Colorado, Maryland, Massachusetts, Minnesota, New York, Vermont, and Washington. These states have enacted regulations and announced programs that specifically address the need for geothermal district-scale heating and cooling systems, albeit using various terminologies (Varela and Magavi, 2024). Policymakers in New Jersey, New Mexico, and Pennsylvania (Figure 37) have sponsored feasibility studies to determine the cost and socioeconomic impacts and benefits of deploying TENs (BDC, 2024).

The New York State Energy Research and Development Authority (NYSERDA) has funded the analysis, design, and/or construction of TENs at over 50 project sites (NYSERDA, 2025). In 2022, the state's Public Service Commission authorized utilities to pilot TENs in all utility territories and six pilot projects are now conducting detailed engineering design of the proposed systems (NY State Senate Bill 2021-S9422, 2022) (Upgrade NY, 2025).

DOE supported the advancement of TENs, including an initiative to design and pilot district-scale geothermal heating and cooling systems in communities nationwide. DOE originally selected 11 projects in 10 states for the initiative: Six urban, four rural, and one remote. In phase one, project teams designed their projects, conducted feasibility studies, and identified workforce and training needs. DOE selected

An Overview of Recent State-Level Geothermal Legislation

Colorado

Colorado recently adopted its first set of rules governing geothermal drilling (ECMC, 2024). The state adopted its Deep Geothermal Operations rules, in addition to a rulebook outlining permitting and enforcement procedures (Colorado Code of Regulations, 2024).

California

In California, Assembly Bill 1359 was approved by the governor in 2024 (CalMatters 2024; Papan, 2024). This amendment allows applicants to request that the county in which a geothermal exploration project is located act as the lead agency for the California Environmental Quality Act review instead of the California Geologic Energy Management Division. It is anticipated that this amendment will help shorten exploration drilling approval timelines in the state.

Washington

Washington State Senate Bill 6039, signed into law in 2024, enhances geothermal deployment on multiple fronts (Washington State Legislature, 2024b). First, it requires the Washington Geologic Survey to compile and maintain a publicly available database of geothermal field information including well logs and surveys. Second, it requires the state's Department of Natural Resources to update the existing geothermal lease rates and make them competitive with federal lease rates and those of other western states. Thirdly, it mandates the state's Department of Commerce, in collaboration with other agencies and stakeholders, to organize a cost share grant program to incentivize geothermal exploration drilling.

Lastly, the new law requires state agencies to collaborate with stakeholders (e.g., Tribal governments) in identifying opportunities and risks associated with the development of geothermal resources in the highest resource potential locations in the state (Washington State Legislature, 2024b).

New York, Colorado, Maryland, Massachusetts, Minnesota, Vermont, and Washington

State-level policy has also driven the development of thermal energy networks in some states. New York became the first state to mandate that its major utilities design thermal energy network projects with Senate Bill S9422 (New York State Legislature, 2022). Colorado, Maryland, Massachusetts, Minnesota, Vermont, and Washington also all have legislation that either allows or mandates utilities to develop TENs demonstration projects or pilots.

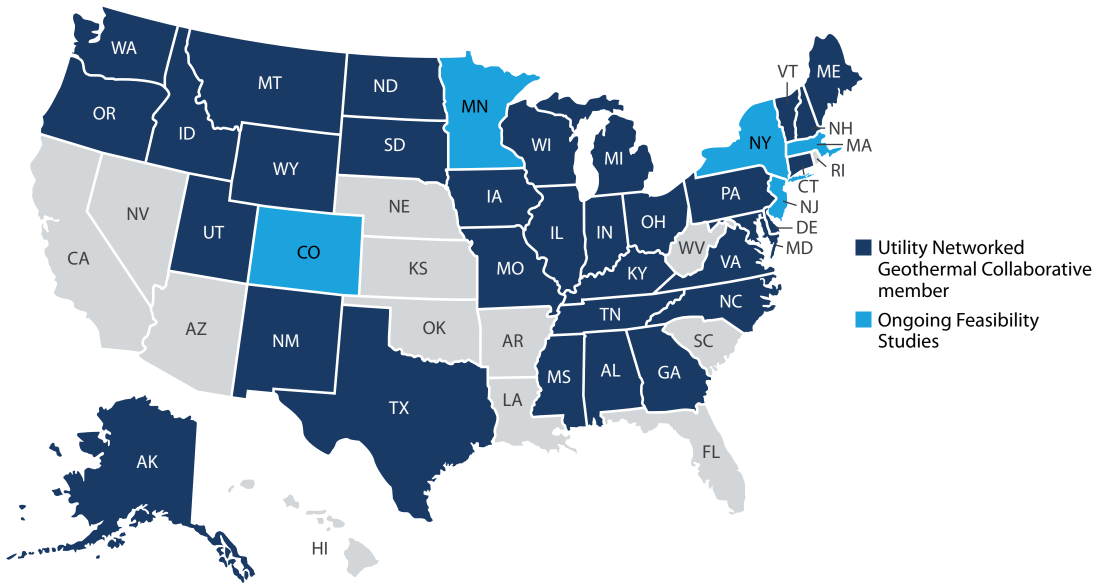

Figure 39. The Utility Networked Geothermal Collaborative has utility members across the country, as well as pilots in 5 states. *Map from Braun (2024).*

five projects to implement their designed projects (GTO, 2025b). The selected pilot project teams received grants totaling $13 million to conduct feasibility studies on their respective project sites by assessing the geothermal resource and permitting needs, conducting economic feasibility analysis and local engagement, and identify workforce and training needs. The program then implemented a second phase involving five of the initial selectees (Figure 38) to install geothermal heating and cooling pilots in their respective communities.

Nationally, utilities are interested in exploring TENs or "networked geothermal" systems. The Utility Networked Geothermal Collaborative began with 10 utilities in 2022 and now includes 27 utilities with a footprint in 29 states and gas utility TEN pilots in five states (Braun, 2024; see Figure 39). The Collaborative allows utilities to work together and share experiences on how to provide networked geothermal systems to customers. Utilities have collaborated on policy mechanisms, business models including a utility rate structure, project sharing, and regulatory framework best practices (Braun, 2024; HEET, 2023).

4.3 Cost Trends

4.3.1 Geothermal Heat Pumps

The cost of a GHP system is driven by equipment (heat pump unit, piping, circulating pump, etc.) and installation (drilling, trenching, grouting, etc.). Equipment costs have regional variance due to differences in tax structures across states, transportation, and supply chains. To determine the extent of variability in GHP system cost, NLR conducted a literature search and performed extensive outreach and interviews with GHP developers, drillers, contractors, and other stakeholders in the industry with the understanding that company- and project-specific information shared during the interviews would not be publicly disclosed. Based on this effort, NLR estimates that the heat pump equipment-only cost excluding installation and any mechanical systems (i.e., piping, circulation pumps, etc.) of large-capacity GHP units (i.e., 5 tons or greater) ranges from $500 to $1,000 per ton of capacity, whereas those of small-capacity GHP units (i.e., less than 5 tons) range from $1,000 to $3,000 per ton of capacity. The cost of the piping loop ranges between $0.5 and $1.5 per foot for Standard Dimension Ratio (11 pipes of diameters 0.75 to 1.5 in.). Cost is affected by the size, type, and efficiency rating of the heat pump.

Based on the NLR survey results, installation costs with respect to drilling boreholes for vertical systems show significant regional variance. The upper limits appear in the Northeast and the low end of the spectrum in the South (Table 4). In states like Massachusetts, New York, and Connecticut, where drillers frequently encounter granite, the per-foot cost to drill a borehole generally ranges between $19/ft and $30/ft, however, it can exceed $90/ft when working with particularly challenging drilling conditions or in regions with drill rig shortages and high demand. Conversely, in Texas and Oklahoma this range was as low as $12/ft to $16/ft. Midwestern states offer a midpoint between these two extremes, with costs typically falling between $16/ft and $18/ft.

Sewer Waste Heat Recovery for Heating and Cooling

The development of networked geothermal heat pump systems has created an opportunity for buildings to utilize novel thermal energy sources, one of which is sewer heat. This waste heat from sewage—wastewater discharged from buildings due to activities like hot showers, laundry, and toilet flushing—is at a higher temperature than other near-surface ground sources, usually 10°C to 30°C (50°F to 86°F) at the point of discharge (Zarnetske and Kohl, 2024). Sewer waste heat can be recovered and utilized for space heating and cooling and for domestic water heating at single building and district scales.

Based on a design being deployed by SHARC Energy, a wastewater energy transfer technology developer, the heat recovery system comprises an underground holding tank that temporarily stores the wastewater. When heating or cooling is required, a pump delivers the wastewater into a macerator and then a filtration unit. The filtered wastewater then flows through a plate heat exchanger that extracts its thermal energy and delivers this as heat through circulation pumps to a water-to-water heat pump (SHARC Energy, nd).

Multiple single-building sewer waste heat recovery projects have been completed in the U.S., including at the DC Water Headquarters in Washington, DC. The sewer heat recovery system provides heating and cooling to 151,300 ft^2 of building space and supplies the building hot water (SHARC Energy, 2020). The system reduces energy use for heating and cooling by 48%. In 2021, the DC Water building achieved LEED Platinum Class A certification1, the highest attainable level for a new building.

The development of 5G district heating and cooling systems that utilize thermal energy from fluids at ambient temperatures has opened up the application of sewer waste heat utilization at the district scale. A foremost example is at the National Western Center, a developing 250-acre urban food and agricultural hub, in Denver, Colorado. The sewer heat recovery system is projected to meet 90% of the center's heating and cooling load (National Western Center, 2025). As shown in Figure 40, the heat recovery system will be housed within a central utility plant—fitted with a filtration system, heat exchanger, and water-to-water-heat pump—that distributes and receives thermal energy through a closed-loop of underground pipeline networks to and from multiple connected buildings at the center (National Western Center, 2025). A similar project is ongoing at the Alexandria Center for Life Science – South Lake Union, in King County, Washington (King County, 2023).

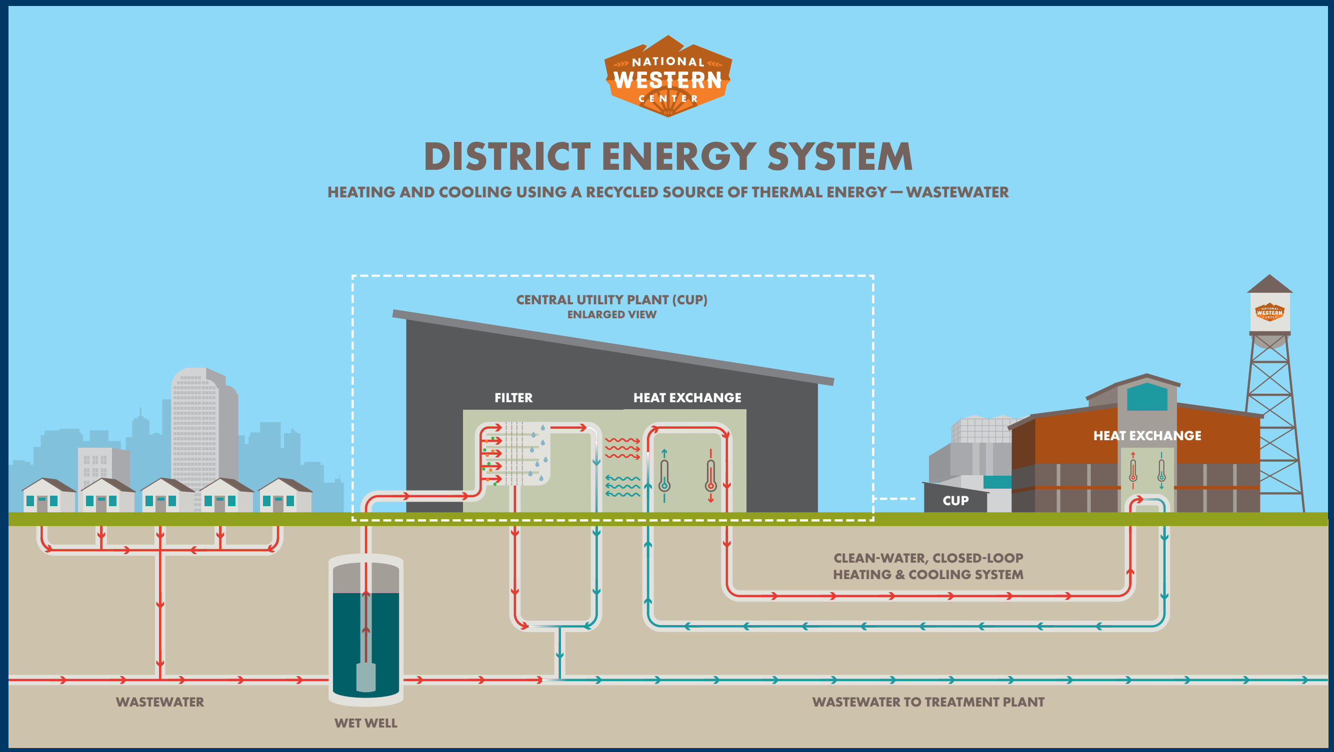

Figure 40. An illustration of the sewer waste heat recovery district energy system design for the National Western Center, Denver CO. *Figure from the National Western Center (2025).*

Framingham, MA: The First Utility-Owned TEN

The first appearance of a "geothermal-based" TEN or geothermal network in state policymaking was in November 2019 in Docket No. 19-120 of the Massachusetts Department of Public Utilities regulatory proceeding. In the filing, a major utility in the state, Eversource Energy, proposed to implement "a utility-owned geothermal network demonstration project that would be an alternative to natural gas for home heating and cooling" (City of Boston, 2020). The Massachusetts Department of Public Utilities approved Eversource Energy's proposal to assess the cost and benefits of constructing a geothermal network in December 2020 (City of Boston, 2020). The first phase of the pilot project in Framingham, Massachusetts, has been completed, and the system is 95% operational as of December 2024 (Shemkus, 2025).

The Framingham TEN is the first utility-owned TEN pilot in the United States. The system consists of an ambient temperature loop that connects decentralized GHPs in 36 buildings, including 24 residential and five commercial buildings, to three borehole fields (Eversource, 2025). The project is financed by Eversource using a ratepayer-based financial structure typically used by gas utility companies (Varela and Magavi, 2024). A second pilot that expands from the current installation is being planned for installation in 2026 (Shemkus, 2025).

Following Eversource Energy's project approval, another utility operating in Massachusetts, National Grid, requested and received approval from the Massachusetts Department of Public Utilities for a networked geothermal demonstration project in Boston (National Grid, 2023, 2024). National Grid will develop this TEN pilot in the Franklin Field Apartments located in the Boston neighborhood of Dorchester. The project is anticipated to replace an aging natural gas boiler loop with a TEN that provides heating and cooling to seven multifamily apartment buildings (National Grid, 2024).

Due to the traction gained in developing utility-owned TENs by Eversource Energy and National Grid, the Massachusetts Department of Public Utilities released an order (Order 20-80) requiring gas distribution companies in the state to consider non-gas alternatives to gas expansion projects, including networked geothermal (Department of Public Utilities, 2023). Following this order and the completion of Eversource Energy's TEN pilot project, the Pipeline Safety Division of the Massachusetts Department of Public Utilities issued the nation's first Networked Geothermal Safety Guidelines in July 2024. These guidelines provide definitions and safety directives to ensure compliance with the state's existing laws, regulations, and utility safe-operating practices and are applicable only to "closed-loop geothermal systems of interconnected ground-source heat pumps" (Department of Public Utilities, 2024).

Photo from HEET

TABLE 4. Distribution of GHP Drilling cost in the Northeast, Midwest, and South

Drilling Cost per Foot	Region		
	Northeast	Midwest	South
Minimum	$19	$16	$12
Median	$25	$17	$14
Maximum	$90	$18	$16

Source: NLR interviews with developers and drillers

These costs are representative of a completed borehole with U-bend loop and grout included. The isolated cost for U-bend loop and grout varies between $1 and $3/ft depending on the U-pipe type and size, and grouting type. The variation in the ranges provided was generally attributed to a few different factors such as difficult geologic conditions, borehole size, depth of bedrock and water table, and wastewater and ground cuttings management and disposal requirements. These factors affect the drilling speed and drilling time, which in turn influence the drilling costs. For example, the time required to drill a 600 ft deep borehole in sandstone formations typical in the Midwest is around 6 hours. In comparison, it takes around 12 hours to drill a 600 ft deep borehole in the hard rock formations found in the Northeast. This difference in time requirements for drilling in hard rock is reflected in the higher per foot price of the Northeast.

Projects requiring wastewater and/or ground cuttings management, i.e., capture, storage, treatment, and offsite discharge, can experience inflated costs, which may drive the decision to use an alternative drilling method. Drilling costs also vary between residential and commercial systems, with commercial systems in the Northeast at $40–$50/ft ($65/ft with prevailing wage requirements). There are, however, efficiency gains in drilling for larger systems, which in some cases reduce the costs for large-scale projects, taking advantage of economies of scale. For example, for some commercial-scale projects not requiring deep drilling and prevailing wages costs as low as $15/ft for drilling and ground loop installation have been noted. Trenching costs follow a similar trend, with Northeast costs around $48/ft per foot and Midwest costs around $18/ft.

Another factor impacting drilling costs for GHP systems is the diameter of the boreholes to be drilled. For example, 4.5-in. and 6-in. diameter boreholes have different material extraction and energy requirements for drilling. Reconstruction costs, such as redoing asphalt, can also increase the project costs. Overall, geothermal installers suggest that drilling costs represent 50%–60% of total system cost, the heat pump and other equipment 30%–40%, and engineering and design 1%–4%.

Technological advancements have propelled the GHP market forward by improving system performance and reducing costs. Innovations in drilling techniques, heat exchangers, and system controls have made GHP installations more efficient, reliable, and affordable (Gi-4, 2025; Washington Post, 2025). As these technologies mature, economies of scale drive down the costs of both equipment and installation, making GHPs more competitive with other HVAC options.

As shown in the analysis in Section 4.1.2, GHPs account for only 1% of the residential dwelling unit primary heating systems in the United States. Widespread adoption is hindered by multiple barriers, including high installation cost. Although GHPs often offer long-term savings through reduced energy use and maintenance, the initial investment—especially in drilling and ground-loop installation—can be challenging for consumers to finance. This is especially true for residential customers, who may lack access to affordable loans or financing options for energy upgrades. Even with long-term savings, the lengthy payback period can deter some from investing in GHP systems. Some companies offer favorable financing or incentives to reduce this cost barrier. For example, Dandelion Energy, a GHP technology provider and project developer, offers a GHP financing option through the EnergizeCT loan program in Connecticut as of June 2025 (Dandelion Energy, 2021). Within this program, homeowners repay the cost of installing a GHP as a monthly fee within their electric bill. Another developer, Brightcore Energy, spearheaded the inclusion of the Thermal Conductivity Testing Incentive program into Con Edison's Clean Heat Program in New York City (Brightcore, 2024). This incentive program creates an avenue for non-residential building projects to offset the costs of conducting thermal conductivity tests by 50%. A recent federal policy change could also be potentially favorable for residential consumers. As of July 4, 2025, GHP systems are now exempt from the IRS policy of limited-use property doctrine, allowing GHP systems to be leased by a third-party, including to residential consumers (Section 50 of U.S. Code 2025c). This could open up positive financing options for residential consumers.

GHP deployment is also limited by contractor expertise in GHP installation and maintenance. The specialized knowledge required for geothermal systems means that not all HVAC professionals are equipped to handle these projects. In some instances, HVAC installers do not offer GHPs as an option for customers even if they are knowledgeable about GHPs. These challenges can make it difficult for consumers to find qualified installers, especially in regions where geothermal technology is less established. Regulatory and permitting challenges also complicate installations in some areas, with restrictions on drilling and water use adding complexity and cost to GHP projects.

Despite these challenges, there is potential for cost reductions as the GHP market continues to grow. Increased competition among manufacturers, advancements in drilling technologies, and economies of scale are likely to reduce prices over time. As contractors gain more experience and the supply chain becomes more efficient, installation costs are expected to decrease and financing options are expected to increase, making GHPs more financially accessible to a broader audience. Technology innovation, workforce experience, and innovative business structure position GHPs well for future growth.

4.3.2 Costs of GDU Systems

The costs associated with GDU projects can be divided into several key components. Initial capital costs, such as drilling, equipment, and infrastructure, represent a significant portion of the investment. Drilling often represents the majority of costs; however, recent drilling performance and cost improvements in geothermal power (described in Section 3.3.3) may be transferable to GDU. Equipment, including heat exchangers, pumps, and piping systems, along with the necessary infrastructure to distribute geothermal heat, also add to the overall upfront costs. Additionally, navigating the regulatory environment can be challenging, as local permitting requirements, environmental regulations, and zoning laws vary significantly across regions. This introduces variances in project timelines and project financing costs. Once operational, GDU systems incur maintenance expenses, including labor, energy, and equipment upkeep. Based on a sample of GDU district heating systems in the United States, the LCOH ranges from $18–$128/MMBtu, with an average value of $65/MMBtu (see Robins et al., 2021), but note that numbers have been adjusted to 2023 USD.

Economies of scale and regional variations also play a significant role in determining the overall cost of GDU projects. Larger projects tend to benefit from reduced per-unit costs, especially for circulating pumps and heat exchangers, while location-specific factors, such as geological conditions, can impact system costs. For example, deeper wells or lower-temperature resources can drive up costs, whereas regions with shallow, high-temperature reservoirs may offer more cost-effective opportunities.

Financing GDU projects can be challenging due to the high upfront costs, but a range of options are available. Loans, grants, and public-private partnerships can help offset the financial burden, while venture capital and private equity are increasingly playing a role in funding innovative GDU projects. For more information on programs and available incentives see Section 5.3.

4.3.3 Costs of Geothermal District Heating and Cooling on College Campuses

Flagship geothermal district heating and cooling systems on college campuses include those installed at the Colorado Mesa University, Ball State University, and Miami University (Oh and Beckers, 2023). Colorado Mesa University in Grand Junction, Colorado, has installed a TEN (5G district heating and cooling system), comprising decentralized GHPs connected to an ambient temperature loop, 471 boreholes, and supplemental cooling towers and boilers, for 16 campus buildings (Oh and Beckers, 2023). Colorado Mesa University reported that this TEN is interconnected with the campus swimming pool and irrigation system, utilizing these sources as a heat sink (Oh and Beckers, 2023). The combination of ground heat exchangers and the additional heat sinks minimizes the operation of supplemental cooling towers and boilers. Total construction cost for the TEN was $20.2 million, and the GHP system and loop field costs were $3,284/ton and $30/ft, respectively (Oh and Beckers, 2023). The university saves $1.5 million in energy costs every year, and nearly $12 million in total since 2008, all while providing 90% of the thermal energy required to operate the campus.

The district system at Ball State University is a 4G centralized heating and cooling system. The system consists of four heat recovery chillers of 2,500 tons connected to 3,600 boreholes at 400 ft depth. Installation of the district heating and cooling system resulted in 40% reduction in steam production needs from existing coal- and natural gas-fired boilers at the central plant, which correspondingly led to annual cost savings of about $746,200 (Oh and Beckers, 2023).

Miami University, in Oxford, Ohio, constructed a 4G system with a centralized plant that provides heating and cooling to 10 buildings. The total system cost was $2,420/ton and the distribution pipe cost was $19/ft (Oh and Beckers, 2023). The installation of the district has led to a 65% decrease in energy costs and 39% decrease in total energy consumption, despite a 25% increase in gross square footage (Oh and Beckers, 2023).

4.4 Future Opportunities

4.4.1 GHP Data Collection

There is a major opportunity to improve the amount and quality of data available on geothermal heating and cooling systems. NLR has compiled a database[32] comprising 70,470 records of site-level residential GHP installations (Pauling, Podgorny, and Akindipe, 2025); however, the database would benefit from additions and refinement. The compiled records are sourced primarily from well permits and small-scale studies; they do not include horizontal loop configurations, which have historically been predominant in rural areas. Well permits also lack critical information such as installed capacity, costs, and performance metrics. Of the 70,470 records identified, 98.4% include geographic coordinates, but data on capacity and costs appear in less than 1.5% of the entries. Capacity and cost metrics are mostly from specialized studies on specific GHP systems and are not broadly applicable across the entire dataset.

[32] Other organizations track GHP installations as well, such as the Air-Conditioning, Heating, and Refrigeration Institute (AHRI), which tracks extended range water-source heat pumps (AHRI, 2025), and the Department of Treasury/IRS, which tracks the number of residential energy credit filings (IRS, 2025b).

Permitting practices for GHP systems differ significantly across states. Drilling permits may be managed by a range of state agencies, including those overseeing environmental protection, water rights, natural resources, health, or engineering. This variation in oversight complicates data collection, as each agency may have distinct reporting standards and levels of data accessibility. Even when well permits are publicly available and easy to access, they may not always specify whether the end use involves heat pumps. To ensure the accuracy and relevance of the data, NLR excluded any permits that did not clearly indicate GHP use from the assessment. Despite these challenges in data collection, state well permits still offer insights into GHP installations across different regions. Note that this report does not include the breakdown of state regulatory frameworks for GHP installations or any data that tracks permitting.

Figure 41 shows the distribution of known GHP installations across the United States as identified through NLR's research and compiled database. The eastern half of the United States has a much denser distribution than the western half, which may be due to higher population density and subsequently greater demand for heating and cooling solutions. Further analysis on the distribution of GHP installations would aid in determining why or how the distribution occurs. As noted, horizontal loop configurations are not included in the compiled data but are the predominate configuration in rural regions; as such, those regions may be underrepresented. Also, this actual site-level GHP installation distribution (although incomplete) is not directly comparable to the state-level estimated GHP deployment map in Figure 30 due to differences in data sources (well permits versus survey responses), data aggregation (actual project count versus extrapolated survey responses), and spatial resolution.

4.4.2 GHP Market Growth

The market for GHPs appears poised for growth, driven by several opportunities. Increased installations, for example, through planned mass residential developments by Dandelion and Lennar (DiNardo, 2025), may help to reduce capital cost of major components and increase standardization of GHP technology. Innovations such as more efficient heat pumps, drilling technology advancement, innovative ground-loop materials, and smarter control systems could increase system performance and reduce

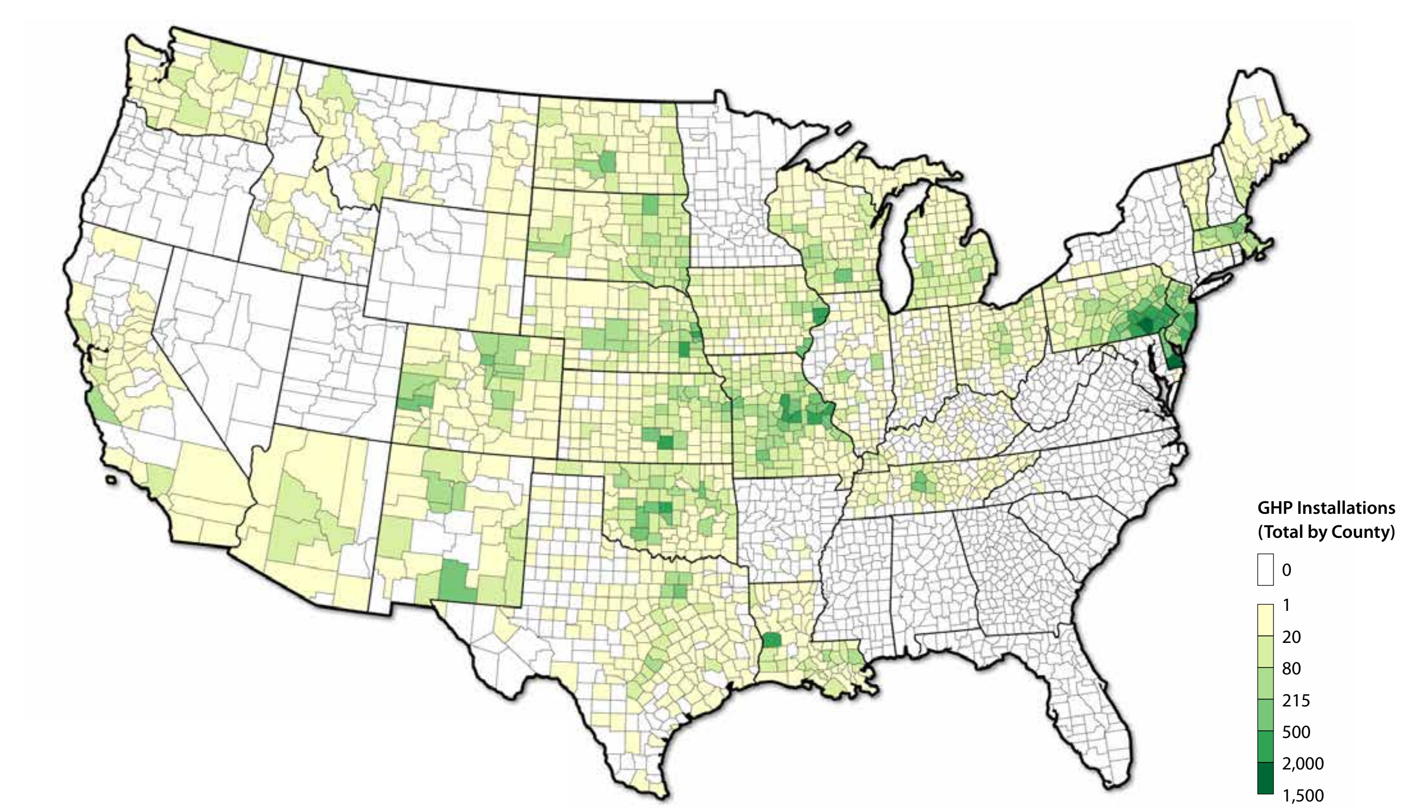

Figure 41. Geospatial distribution of GHP installations based on data compiled by NLR for this report. *This database is not comprehensive.*

operational costs. Additionally, the integration of GHPs with other energy technologies, such as solar photovoltaic (PV), solar thermal, and energy storage, holds the potential to create comprehensive, hybrid energy solutions for homes and businesses. This integration could provide a reliable energy source for both heating and cooling. New market segments, such as multifamily housing, commercial buildings, and industrial applications, could also provide opportunities for GHP market growth.

4.4.3 Geothermal District Heating and Cooling Opportunities

Moving forward, geothermal district heating could benefit from additional data collection on geothermal district installations, both for direct use and TENs, to aid in better understanding of the current and future market. Continued market opportunities may occur with growing state-level support for TENs and the potential for EGS to increase GDU for district heating. Continued innovations in GHPs and drilling will also directly benefit deployment of TENs. Additionally, the expansion of geothermal districts into retrofits will expand the growing market.

4.4.4 Geothermal Cooling and Data Centers

In addition to the geothermal power for data centers discussed in Section 3.7, shallow geothermal systems offer an extensive resource that can be purposed for reducing data center cooling load. This could potentially be enabled by underground thermal energy storage (Section 6.4). A recent study by three national laboratories confirmed the techno-economic feasibility of using underground thermal energy storage integrated with dry coolers to meet the cooling demand of data centers of varying size and geographic locations for up to 20 years (Oh et al., 2025; Zhang et al., 2025).

4.4.5 Geothermal Heating and Cooling at Federal Sites

The prospects for geothermal heating and cooling are expanding at federal sites. The Federal Geothermal Partnership between DOE's GTO and the Federal Energy Management Program (FEMP) is leading efforts to expand geothermal heating and cooling at federal sites. Using funding provided through the Federal Geothermal Partnership, Oak Ridge National Laboratory and its partners are performing analysis and site-specific work required to bring geothermal heating and cooling solutions to two military installations—the U.S. Military Academy at West Point and the U.S. Army's Garrison Detroit Arsenal in Michigan (Sabin and Blake, 2023). As of May 2024, an exploration well for geothermal heating and cooling has been drilled at the Detroit Arsenal. This well will provide important data to update subsurface characterization and for building energy modeling for the proposed geothermal pilot (Burnley, 2024).

4.5 Value of Geothermal Heating and Cooling to the Grid

A recent analysis led by Oak Ridge National Laboratory (ORNL) has shown that deploying individual GHPs into 68% of the total existing and new building floor space in in the conterminous United States by 2050 can create multiple benefits (Liu et al., 2023). ORNL concluded this level of GHP deployment can reduce electricity demands and the need for increased power generation and grid infrastructure.

Specifically, mass GHP deployment is estimated to reduce required additional annual generation by 585–937 TWh and power and storage capacity by 173–410 GW (Liu et al., 2023). Mass GHP deployment is also expected to alleviate the need for transmission build outs by 3.3–65.3 TW/mile. Additional benefits include reduced electric power system costs (by 5%–7%), wholesale marginal cost savings of $316–606 billion, summer peak load reduction due to efficient cooling (by 3%–28%), and improved operational reliability for the grid (Liu et al., 2023).

4.6 Policy Case Studies

4.6.1 Geothermal Heat Pump Policy Case Studies

STATES AND D.C. DATA

As of December 2025, 34 states and D.C. have incentive policies for geothermal heat pumps

This includes grants, rebates (e.g., cash rebate), tax incentives (e.g., property tax deduction or personal tax deduction), and other financial incentives[33] (e.g., reduced cost and/or free application fees for permit processing).

As of June 2025, 23 states and D.C. have existing regulatory policies for geothermal heat pumps

This includes but is not limited to energy and efficiency standards, net metering (or lack thereof), and interconnection standards.

FEDERAL DATA

As part of the Inflation Reduction Act (IRA) Residential Energy Efficient Property Credit, homeowners were eligible for a 30% tax credit on GHPs which was available through 12/31/2025 (26 USC § 25D; U.S. Code 2025a). The IRA also includes a base 6% tax credit for commercial building owners installing GHPs (26 USC § 48E; IRS, 2025a).

INCENTIVE POLICIES

State Level Existing Incentive Policies for Geothermal Heat Pumps

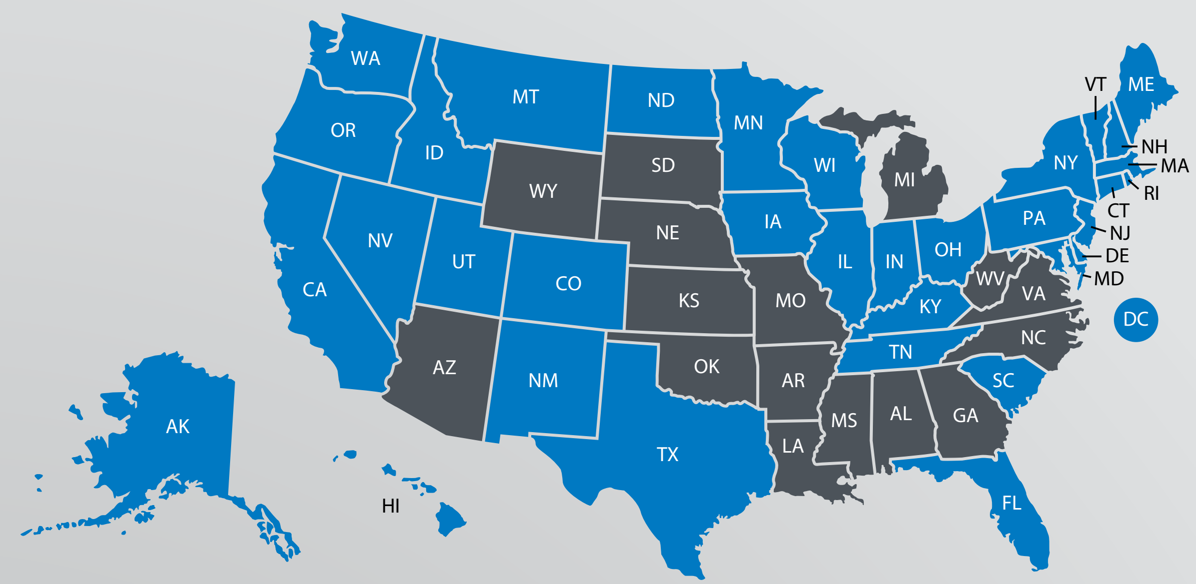

Figure 42. States with GHP incentive policies as of December 2025

COMMERCIAL OR NON-RESIDENTIAL EXAMPLES

South Carolina offers a 10% income tax credit to the manufacturers of qualified energy projects (S.C. Code § 12-6-3588; South Carolina Legislature, 2017).

Virginia offered a $500 tax credit per job created for taxable years 2010–2025 for each new job created in the field of alternative energy, with an annual salary of at least $50,000. Each taxpayer qualified for this section may receive the credit for up to 350 applicable jobs, which includes jobs installing GHPs (Va. Code § 58.1-439.12:05; Virginia State Code, 2023).

Through the Alaska Energy Authority, there are a few grant options available to install qualified energy technologies, including geothermal power, heating, and cooling (3 AAC 107.600 et seq.; Alaska State Legislature, 2025).

RESIDENTIAL EXAMPLES

The Colorado Energy Office offers a Heat Pump Tax Credit for space heating and cooling. The pumps must be ENERGY STAR certified (HB21-1253 [Colorado State Legislature, 2021a]; SB21-230 [Colorado State Legislature, 2021b]; HB22-1381 [Colorado State Legislature, 2022]). Customers may receive up to $3,000 for installation (HB21-1253; SB21-230; HB22-1381; Colorado State Legislature, 2021a, 2021b, and 2022).

Idaho allows taxpayers to claim a tax reduction of 40% of the cost of GHPs for the year of installation and a reduction of 20% of the cost for the following three years (Id. Code § 63-3022C [Idaho State Legislature, 2025). The maximum deduction for one year is $5,000, for a total maximum deduction of $20,000 (Id. Code § 63-3022C [Idaho State Legislature, 2025]).

Rhode Island offers a state sales and use tax exemption for GHPs sold in the state (R.I.G.L § 44-18-30 (57) [Rhode Island Legislature, 2025]).

[33] For the purposes of this analysis, the data collected do not include loans of any type.

UTILITY TAX INCENTIVES FOR GHPs AS OF JUNE 2025

Total number of rebates identified: 315

- 57 investor-owned utility rebates
- 110 public power utility rebates
- 145 cooperative utility rebates
- 3 "other," which includes local, state, and nonprofit organizational rebates.

Rebates

- Rebates have ranges of dollar amounts per ton of cooling capacity of the unit.
- Some include maximum rebates with examples including maximum dollar amounts to total percentages of material costs.
- Total dollar amounts were typically based on a unit type.

States with Available Utility Incentives for GHPs

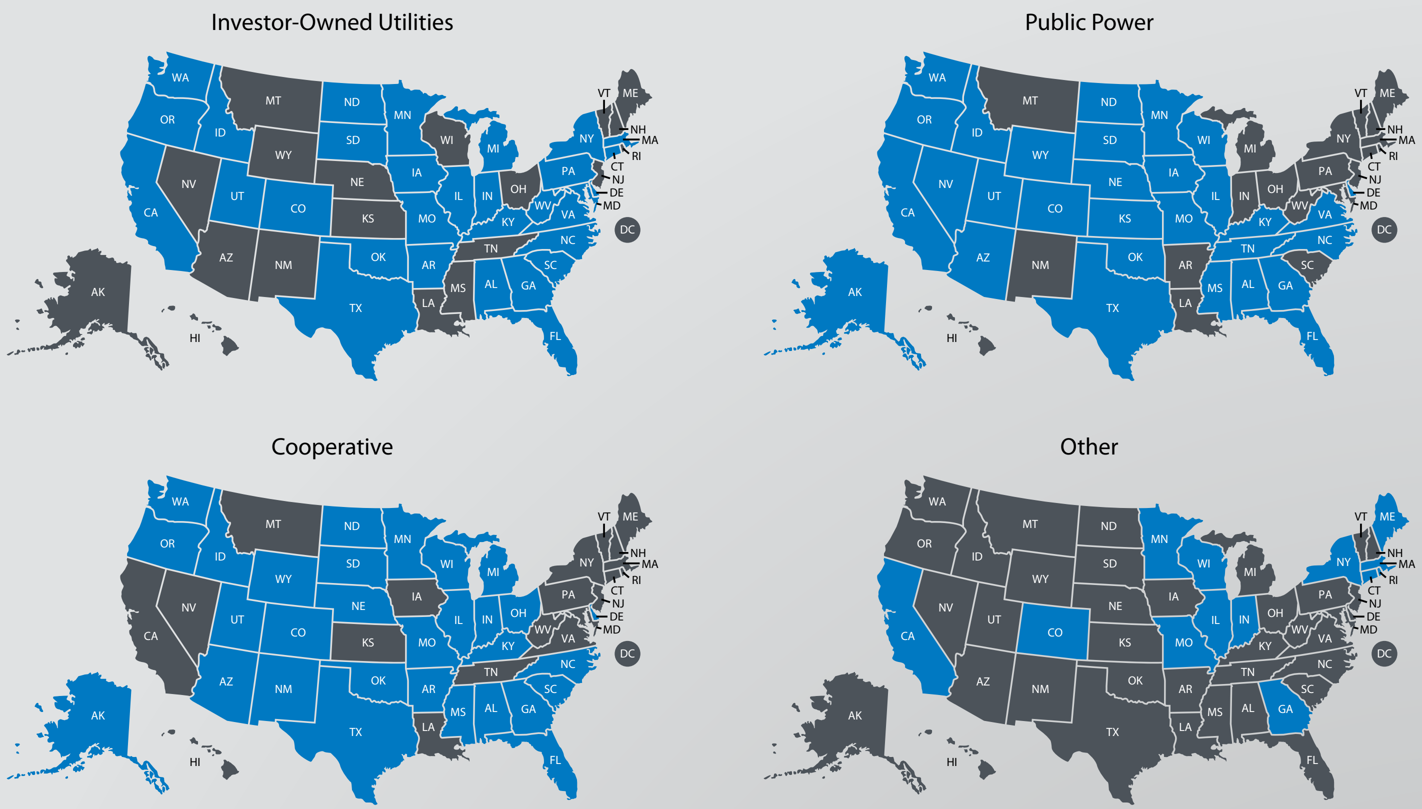

Figure 43. GHP utility incentives in the United States. *For further information, see Appendix D.*

EXAMPLES OF EXISTING UTILITY REBATES AS OF JUNE 2025

Orange County Rural Electric Municipal Cooperative in Indiana is a cooperative that offers a $2,000 rebate per geothermal system installed in non-mobile homes (Orange County REMC, 2024).

Bright Energy Solutions, a public power company in South Dakota, offers rebates for residential properties of $200/ton for a GHP and $150/unit for a heat pump water heater (Bright Energy Solutions, 2025).

Portland General Electric in Oregon is an investor-owned utility that offers multiple incentives for heat pump technologies, including an instant discount of $200, $700 for efficient heat pumps, including geothermal heat pumps, and $250 for heat pump controls (Portland General Electric, 2025).

Tampa Electric Company in Florida is an investor-owned utility that offers a $135 rebate for GHPS with an energy efficiency ratio (EER) of 14.00 or higher (Tampa Electric Company, 2025).

Ameren Missouri is an investor-owned utility that offers a rebate ranging from $700 to $1,800 for installation of a GHP (Ameren Missouri, 2023).

TABLE 5. Non-Utility Organizations Offering GHP Incentives as of June 2025
All listed incentives include GHP as qualifying technology.

Organization Name	Location	Brief Summary
City of Boulder	Boulder, Colorado	The City of Boulder offers a $400 rebate for a cold climate heat pump, with an additional $500 rebate if switching from gas. Additionally, they offer a $250 rebate for a heat pump water heater, with an additional $500 if switching from a gas water heater (City of Boulder, 2021).
EnergySmart/Boulder County	Boulder, Colorado	Income-qualified rebates that cover up to 70% of project costs up to $4,000 per year for projects that install a GHP that is 5.5 tons or smaller, 14.1 EER, ENERGY STAR certified. If the unit is replacing a gas furnace or boiler, an additional $100 can be added to the rebates (EnergySmart, 2024). Standard rebates of $400 for gas furnace replacement with a GHP or $300 for electric appliance replacement with a GHP on a first come first served basis. GHP must be 5.5 tons or smaller, 14.1 EER, and ENERGY STAR certified.
Walking Mountains Sustainability	Colorado	Offers a rebate up to $3,000/year for residential properties, $7,500/year for commercial properties, and $5,000/year for low- to moderate-income households (Walking Mountains Sustainability, 2019).
Cloud City Conservation Center (C4)	Colorado	Energy improvement rebates of 50% of the total project cost, up to $300/household (Cloud City Conservation Center, 2025).
Energize Connecticut	Connecticut	Rebate up to $4,000 per ton for qualifying GHPs, with a participating contractor for commercial and industrial electric service customers. Rebate up to $15,000 for qualifying GHPs with a participating contractor for residential customers (Energize Connecticut, 2024).
City of Chicago	Illinois	Expedited permitting process and potential reduction of permit fees for alternative energy projects, which include geothermal systems (City of Chicago, 2025).
Power Moves/Wabash Valley Power Authority	Illinois, Indiana, and Missouri	Residential GHP rebates for closed-loop systems ($250 to replace an existing geothermal system, $2,000 for all other replacements) and open-loop systems ($250 to replace an existing geothermal system, $1,000 for all other replacements), and business/commercial rebates for GHPs ($500–$750/ton) (Power Moves, 2025).
Efficiency Maine	Maine	Rebates of $800–$2,000 for the first heat pump and $400 for a second heat pump (purchased by the same individual) (Efficiency Maine, 2025).
Mass Save	Massachusetts	Residential GHP rebates of up to $15,000/home and commercial GHP rebates of up to $4,500/ton (Mass Save, 2025).
NYS Clean Heat	New York	Rebates and financing information for heat pumps based on home location (NYS Clean Heat, 2025).
Focus On Energy	Wisconsin	Heat pump rebates of $750–$1,000 for residential, multifamily residential, and low-income residential properties (Focus on Energy, 2025).
Bright Energy Solutions	Minnesota	Heap pump rebate of $200/ton (Bright Energy Solutions, 2025).

RECENT PROJECT DEVELOPMENTS

In 2024, GTO published a set of GHP case studies[34] to help people better understand GHP systems, installations, and benefits. These 19 studies detail GHP installations in climate zones across the United States, with varying system types, sizes, and end uses. The results provide real-life examples of GHP systems in different parts of the country, making it easier for people to understand how such a system might work for them. The case studies include web pages and printable versions.

Locations of GHP case studies published by GTO

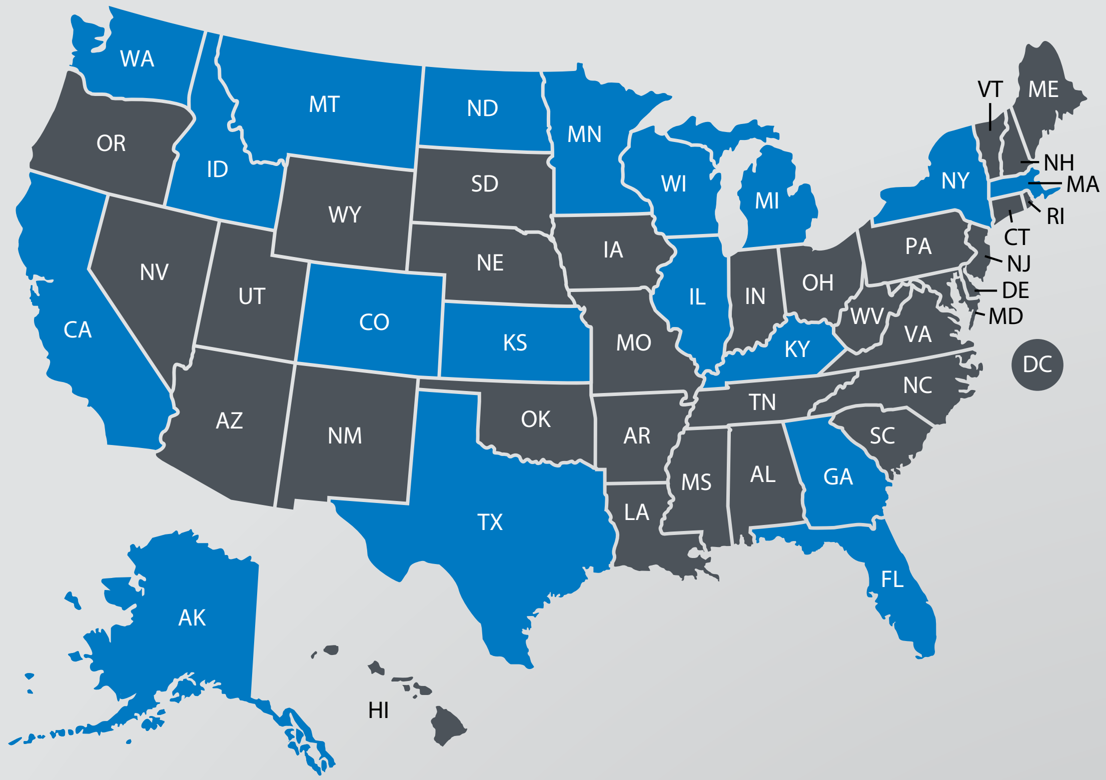

Figure 44. Locations of GHP case studies published by GTO. *Map by NLR; case studies are available at https://www.energy.gov/eere/geothermal/geothermal-heat-pump-case-studies*

4.6 Policy Case Studies

4.6.2 Geothermal Direct Use Policy Case Studies

STATES AND D.C. DATA

As of January 2025 17 states and D.C. have incentive policies for geothermal direct use

This includes grants, rebates (e.g., cash rebate), tax incentives (e.g., property tax deduction or personal tax deduction), and other financial incentives[35] (e.g., reduced cost and/or free application fees for permit processing).

8 states, U.S. Virgin Islands, and Puerto Rico have existing regulatory policies for geothermal direct use

This includes but is not limited to energy and efficiency standards, net metering, and interconnection standards.

[34] Available at: https://www.energy.gov/eere/geothermal/geothermal-heat-pump-case-studies
[35] For the purposes of this analysis, the data collected may include loans, although the focus of the data collected is on free incentives (tax incentives, rebates, etc.).

FEDERAL DATA

As a part of the Inflation Reduction Act's Investment Tax Credit, geothermal direct-use projects may be eligible for a base tax credit of 30% if they were built between 2021 and 2025 (26 USC § 48E; IRS, 2025a).

TABLE 6. GDU Incentive Program Case Studies
All listed incentives include GDU as qualifying technology.

State	Type of Incentive	Brief Summary
Alaska	Grant Program	The Alaska Energy Authority offers a program that includes funding for geothermal direct-use projects with an annual average budget of $10.5 million (Alaska State Legislature, 2025).
Connecticut	Property Tax Incentive	100% tax exemption for qualifying energy projects on properties installed after January 1, 2014, as long as the nameplate capacity does not exceed the load for the property, or the project is connected to net metering (Connecticut General Assembly, 2025).
Nevada	Sales Tax Abatement	New/expanded businesses may apply to the State Office of Energy for a sales and use tax abatement for qualifying energy projects. Approved businesses may pay a sales and use tax rate of 2.6% for 3 years (Nevada General Assembly, 2025).

TABLE 7. GDU Regulatory Policy Case Studies
All listed policies include GDU as qualifying technology.

State	Type of Policy	Brief Summary
Massachusetts	Public Benefits Fund	Public Benefits Fund for GHPs and direct-use applications of $0.0025/kWh (Massachusetts Legislature, 2025a, 2025b).
Oregon	Energy Standards for Public Buildings	Public agencies must spend 1.5% of project costs on qualifying energy technology (Oregon Department of Energy, 2021).
Vermont	Public Benefits Fund	Established in 2005, Vermont's Fund promotes the development and deployment of cost-effective technologies, including GDU (Vermont General Assembly, 2025).

PROJECT EXAMPLES

SPACE HEATING

The College of Southern Idaho has a combined direct-use geothermal and GHPs system to heat buildings directly. This example has been highlighted in GTO's Geothermal Heat Pump Case Study.[36]

DISTRICT HEATING

The City of West Union, Iowa had a closed-loop district geothermal heating and cooling system installed in 2014. This system includes roughly 220,000 ft^2 of downtown commercial space.[37]

Eversource's geothermal heating and cooling network in Framingham, Massachusetts came online in 2024.[38] The project includes a neighborhood, schools, a fire station, and a few commercial buildings. The effort is set to expand in 2025 to include additional homes and a nearby National Guard building.

[36] https://www.energy.gov/eere/geothermal/geothermal-heat-pump-case-study-college-southern-idaho
[37] https://greenupwestunion.com/
[38] https://www.eversource.com/content/residential/save-money-energy/clean-energy-options/geothermal-energy

5. Market Drivers

While recent capacity gains have been modest, there are reasons to believe that the geothermal market could experience rapid growth in the near term. Market growth could result from anticipated improvements to both mature and emerging technologies, as well as emerging value-added uses (e.g., lithium extraction). The expected load growth in the electric grid due to the proliferation of data center and industrial manufacturing hubs across the U.S. is anticipated to increase the demand for baseload, flexible, and resilient energy sources like geothermal. Next-generation geothermal technologies offer potential to expand geothermal nationwide, while TENs provide new opportunities for district heating and cooling.

Photo from Getty sb10067330b-001

This section presents the federal and state policies that regulate and incentivize geothermal energy development for both power production and heating and cooling applications.

5.1 Summary of Existing Federal Policies

5.1.1 Summary of Federal Geothermal Policies

All policies listed are current as of June 2025 and are meant to provide historical context.

Geothermal Steam Act of 1970

The Geothermal Steam Act of 1970 (30 U.S.C. § 23) authorizes the Secretary of the Interior to lease federal lands for geothermal resources (with a few exceptions, including National Parks aside from a few identified significant thermal features). This pertains to the geothermal market as most hydrothermal resources are found in the western United States, which includes a large portion of federal lands that are managed by BLM. The Geothermal Steam Act also provides a distinction between competitive and noncompetitive leasing of federal lands. This includes a 2005 amendment where any party with interest in leasing BLM lands for geothermal exploration and production may nominate specific parcels. The Geothermal Steam Act requires the BLM to hold a competitive auction at least once every two years and simplifies royalty calculations by allowing the payment to be based on the percentage of the value of electricity production.

Public Utilities Regulatory Policy Act of 1978

The Public Utilities Regulatory Policy Act (PURPA) of 1978 was enacted following the energy crisis in the 1970s to promote renewable energy, cogeneration, and small power projects. This included funding specifically for geothermal research and development (R&D) through DOE. PURPA also governs energy purchases by electric utilities from qualifying facilities. These include small power production facilities with a capacity of 80 MWe or less with primary resource coming from a renewable, biomass, or waste to energy source, and cogeneration facilities generating electricity with a secondary thermal resource (i.e., heat or steam). Utilities are required to purchase the electricity from these facilities at avoided cost rates or the operational costs (e.g., fuel, maintenance). PURPA changed the electricity market by opening opportunities for independent power producers. Enactment of PURPA combined with high natural gas prices catalyzed geothermal's growth in the 1980s.

Investment Tax Credit

The Energy Tax Act of 1978 (26 U.S.C. § 1) created the ITC. The ITC initially provided tax incentives for energy conservation and alternative sources of energy. Congress instituted the ITC to address public awareness of environmental pollution as well as the energy crisis brought about by the oil embargo of 1973 and the oil supply problems during the Iranian revolution in 1978 and 1979 (Lazzari 2008; Mormann 2016).

Production Tax Credit

The Energy Policy Act of 1992 created the PTC, primarily to align a tax credit with the electricity production of wind resources for their first 10 years in operation.

Energy Act of 2020

The Consolidated Appropriations Act of 2021 included the Energy Act of 2020, which features portions or all of 37 Senate bills updating national energy policies since the Energy Independence and Security Act of 2007 (42 U.S.C. § 152) (Senate Committee on Energy and Natural Resources, 2020). The Act included specific tax credits for renewable energy resources including geothermal, required the Secretary of the Interior to set goals for renewable energy production on federal lands, and required the Department of Interior to improve federal permitting coordination projects (including geothermal) on federal lands.

The Energy Act of 2020 included significant provisions for research, development, demonstration, and deployment of geothermal energy. Examples include:

- Allocated annual funding for DOE's geothermal research and development activities
- Modified the definition of renewable energy to include geothermal energy
- Authorized up to two new FORGE EGS study sites
- Created the Renewable Energy Coordination Office to improve permitting timelines and coordination between federal agencies
- Directed the United States Geological Survey to update its geothermal resource assessment.

Infrastructure Investment and Jobs Act of 2021

The Infrastructure Investment and Jobs Act was signed into law on November 15, 2021, with a primary goal to provide new funding for major infrastructure projects. The Infrastructure Investment and Jobs Act included provisions to improve geothermal resource data and support supply chains for energy technologies including geothermal. The Act also appropriated $84 million to support EGS pilot demonstrations in different geographic areas and geologic conditions.

Inflation Reduction Act

The IRA was signed into law on August 16, 2022, and includes several provisions for geothermal, including a PTC for the first 10 years of operation of a facility or an ITC equal to 30% of the investment in the facility. Both tax credits can include multiple 10 percentage point bonus for facilities. These bonuses are based on things like meeting specific domestic manufacturing requirements, the location of the project, etc.

The IRA also included an ITC for GHPs up to 30% of the installation cost and expanded the Qualifying Advanced Energy Project Credit (48C), which was established in the American Recovery and Reinvestment Act of 2009. In the IRA, the 30% ITC for residential applications (25D) was scheduled to sunset on 12/31/2032, however, following passage of H.R. 1 in July 2025, the 30% ITC for residential applications (25D) sunsets on 12/31/2025 (IRS, 2025c). The Qualifying Advanced Energy Project Credit is how manufacturers of geothermal technologies can apply to DOE for Section 48C's Advanced Energy Manufacturing Credit (a $4 billion carve-out for coal communities). The IRA also expanded the DOE Loan Guarantee Program for large-scale energy projects including geothermal energy projects.

5.2 Summary of Existing Federal Incentive Policies

The following tables provide a summary of existing federal policies for geothermal technologies.

TABLE 8. Federal Incentive Policies for Geothermal Heating and Cooling

Incentive Type	What Sector(s) does the Policy Apply to?	Citation
Financial incentive (tax credit)	Residential	Internal Revenue Code Section 25 D (U.S.C. 26 25D)[39]
Financial incentive (rebate)	Residential	HEAR Program[40]
Financial incentive (grant)	Small businesses—cooperatives, electric utility, tribal business entity, or agricultural producer.	REAP Grants[41]

TABLE 9. Federal Incentive Policies for Geothermal Power

Incentive Type	Citation
Financial incentive (PTC)	CFR Section 45Y[42]
Financial incentive (ITC)	CFR Section 48E.S4[43]

For incentives and policies by state, please see Appendices D and E

5.3 Summary of Leasing and Permitting on Public Lands

Geothermal development has historically been subject to long permitting timelines resulting from multiple environmental reviews, leasing delays, staffing shortages at regulatory agencies, and other factors.

5.3.1 Bureau of Land Management Permitting Timelines

The permitting process for geothermal projects on public lands (i.e., BLM-managed lands) has historically taken 7–10 years (Figure 45), which can include several reviews under the National Environmental Policy Act. Projects are unique and can vary in complexity, so permitting processes and timelines can also diverge.

As of August 2024, there were five geothermal projects in the BLM permitting queue. Four of these projects are in Nevada and one is in Utah.[44]

5.3.2 Updates to Geothermal Permitting on Bureau of Land Management Lands

Categorical exclusions to the National Environmental Policy Act (NEPA)—a class of actions determined to not have a significant effect on the human environment and therefore excluded from NEPA review—are intended to streamline reviews and help agencies focus on actions with the greatest potential for impact, as displayed in Figure 45. Recent BLM adoption or proposals for new categorical exclusions aim to streamline various aspects of geothermal development.

On April 19, 2024, BLM adopted two categorical exclusions[45] pursuant to section 109 of the National Environmental Policy Act for geothermal exploration operations (89 Fed. Reg. 28797, 28799). The adopted USFS categorical exclusion[46] supports the approval of short-term (one year or less) pre-lease or post-lease geothermal exploration projects and the construction of less than 1 mile of low standard road (i.e., a minimally designed road that is not crowned or ditched) (89 Fed. Reg. 28797, 28798, 28799). By comparison, the adopted

[39] https://www.irs.gov/credits-deductions/residential-clean-energy-credit
[40] https://www.energystar.gov/partner-resources/state-and-tribal-rebate-programs/hear-program
[41] https://www.rd.usda.gov/inflation-reduction-act/rural-energy-america-program-reap
[42] https://www.ecfr.gov/current/title-26/chapter-I/subchapter-A/part-1
[43] https://www.ecfr.gov/current/title-26/chapter-I/subchapter-A/part-1
[44] For more information on specific projects, visit https://eplanning.blm.gov/eplanning-ui/home
[45] The 2024 categorical exclusions adopted are as follows: (1) USFS Categorical Exclusion for Short-Term Mineral, Energy, or Geothermal Investigations, and (2) Department of Navy Categorical Exclusion for Pre-Lease Upland Exploration Operations Activities for Oil, Gas or Geothermal Preserves (Adoption of Categorical Exclusions Under Section 109 of the National Environmental Policy Act, 89 Fed. Reg. 28797; April 19, 2024). The purpose of the adopted categorical exclusions is to facilitate permitting of Notices of Intent to Conduct Geothermal Resource Exploration operations, which would normally require preparation of an environmental assessment to comply with the National Environmental Policy Act (89 Fed. Reg. 28797, 28799).
[46] The BLM has further clarified that although under the adopted USFS categorical exclusion exploration activities would have to be concluded within one year, implementation of reclamation may take longer and require extended monitoring to evaluate success (89 Fed. Reg. 28799).

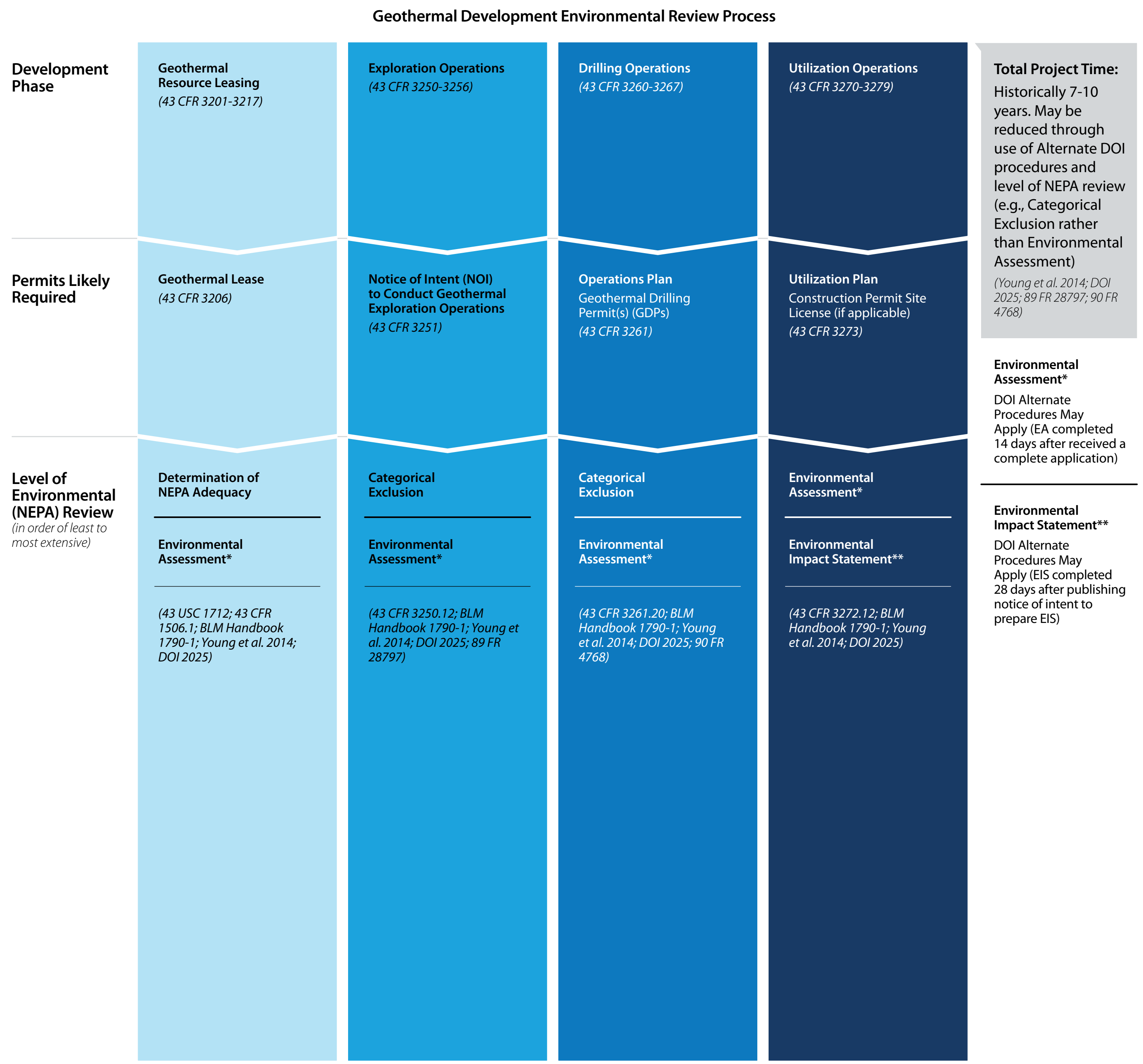

Figure 45. Project permitting and construction timeline on public land. *Figure by NLR. Sources: Federal Land Policy and Management Act of 1976 (U.S. Code 2025d), the BLM Handbook 1790-1 (BLM 2008), Young et al. (2014), U.S. Department of the Interior (2025), 43 Code of Federal Regulations (CFR) Part 3200—Geothermal Resource Leasing (Federal Register 2007), NEPA Implementing Procedures notice (Federal Register 2025), and the Adoption of Categorical Exclusions notice (Federal Register 2024).*

Department of Navy categorical exclusion is limited to pre-lease geothermal exploration operations and does not apply to post-lease geothermal exploration operations (89 Fed. Reg. 28798). However, unlike the USFS adopted categorical exclusion, the adopted Department of Navy categorical exclusion does not provide any limitations prescribing the length of time in which exploration operation projects must be concluded (89 Fed. Reg. 28798). Notably, neither of the adopted categorical exclusions specify a surface disturbance acreage limitation. The BLM considers site-specific factors and extraordinary circumstances when determining the acreage amount of surface disturbance to be authorized under either adopted categorical exclusion (89 Fed. Reg. 28799). Further, although both adopted categorical exclusions reference mining and/or oil and gas exploration, the Department of Interior has clarified that both adopted categorical exclusions are meant to apply exclusively to geothermal exploration operations (89 Fed. Reg. 28799).

In addition to the USFS categorical exclusions adopted by the BLM, in November 2022 and those described above, the Department of the Interior adopted 23 other categorical exclusions from other federal agencies aimed to improve permitting timelines (Department of Interior, 2022).

In January 2025, BLM adopted a categorical exclusion that covers geothermal resource confirmation drilling in sites of up to 20 acres. Eligible drilling activities include core drilling, temperature gradient wells, and/or resource wells to confirm the existence of a geothermal resource, improve injection support, or demonstrate connections between wells. This categorical exclusion has the potential to shorten permitting for geothermal projects by up to one year.

Also in January 2025, BLM proposed an additional categorical exclusion related to geothermal resource exploration operations. This would allow a Notice of Intent to Conduct Geothermal Resource Exploration Operations to encourage activities related to the search of indirect evidence of geothermal resources (Federal Register, 2024). This categorical exclusion does not include direct testing of resources or utilization and cannot exceed 10 acres total of surface disturbance (Federal Register, 2024).

5.3.3 BLM Leasing Data Review

The Energy Policy Act of 2005 (GPO, 2005) and updated 43 CFR 3200 leasing regulations changed BLM leasing policy to a default competitive leasing process (Federal Register, 2007). The policy mandates competitive leasing, whereas the previous policy only required competitive leasing for lands within a known geothermal resources area; lands from terminated, expired, or relinquished leases; or at the discretion of BLM. However, parcels that do not receive a competitive bid remain available for noncompetitive leasing for two years following the lease sale.

BLM leasing data were obtained from the annual BLM Public Land Statistics reports (BLM, 2023a; 2025b). The compiled annual lease sale results include existing leased acres, new leased acres, and the total bonus bid. As of September 2024, 568 producible leases (i.e., leases on land that have at least one active well) have been issued on BLM land, totaling 1,201,122 acres (BLM, 2025b). These projects are listed in Table 10.

TABLE 10. Competitive and Noncompetitive Leasing Data for Geothermal on BLM Land.
All leases are as of Sept. 30, 2024.

	Competitive Geothermal Leases Prior to Energy Policy Act of 2005		Competitive Geothermal Leases Under the Energy Policy Act of 2005		Noncompetitive Geothermal Leases	
	Number	Acres	Number	Acres	Number	Acres
California	31	42,607	24	26,012	12	8,318
Colorado	-	-	2	1,204	-	-
Idaho	-	-	1	1,739	-	-
Nevada	31	24,998	237	578,888	149	364,824
New Mexico	1	280	4	11,870	2	2,867
Oregon	-	-	4	3,145	16	12,093
Utah	6	5,128	27	61,408	20	50,776
Washington	-	-	-	-	1	4,965
Totals	**69**	**73,013**	**299**	**684,266**	**200**	**443,843**

Ground Source Heat Pump Measures Installed Under the DOE ESPC IDIQ Program

DOE's Federal Energy Management Program (FEMP) supports implementation of energy conservation measures (ECMs) through its Energy Service Performance Contracts (ESPC) Indefinite Delivery, Indefinite Quantity (IDIQ) contract and maintains a database of projects awarded. This analysis of geothermal (or ground-source) heat pump (GHP) technology ECMs deployed in past projects leverages that dataset to understand GHP ECM impacts on ESPCs.

Twenty-seven GHP ECMs were identified in 24 separate projects awarded between 2001 and 2014. Projects were located throughout the United States (Figure 46), with most projects located in the eastern United States.

GHP ECMs were installed at a variety of building types, as seen in Figure 47, ranging in size from 8,000 square feet at a single location to nearly 300,000 square feet across 10 buildings at a single site.

Cost savings from GHP ECMs resulted from reductions in energy use, water use, and operations and maintenance (O&M) costs. Not all projects included water or O&M savings, and savings due to GHP tax incentives were not incorporated in this analysis. Figure 48 shows the distribution of energy savings by energy type.

Energy savings were responsible for 75% of the total cost savings, O&M savings for 24%, and water savings for 1%. Removing outliers, the average simple payback is 41.6 years, and the median is 24.4 years. Figure 49 illustrates how this simple payback for GHP measures shifts after removing any O&M savings attributed to the GHP ECM. When only considering projects with O&M savings, the simple payback for the GHP ECM is 20.6 years on average.

O&M cost savings significantly impacts the simple payback of GHP ECMs, which in turn can impact the economic viability of the measure.

GHP ECMs have been successfully implemented at multiple federal facilities and building types in ESPCs, resulting in significant energy and O&M savings.

This subsection was authored by John Shonder, Oak Ridge National Laboratory (ORNL); Christine Walker, Pacific Northwest National Laboratory (PNNL); and Miranda Heiland, PNNL.

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Note this analysis is limited to data provided in Task Order (TO) schedules at project award, produced prior to final design; final ECM design does not occur until after TO award.

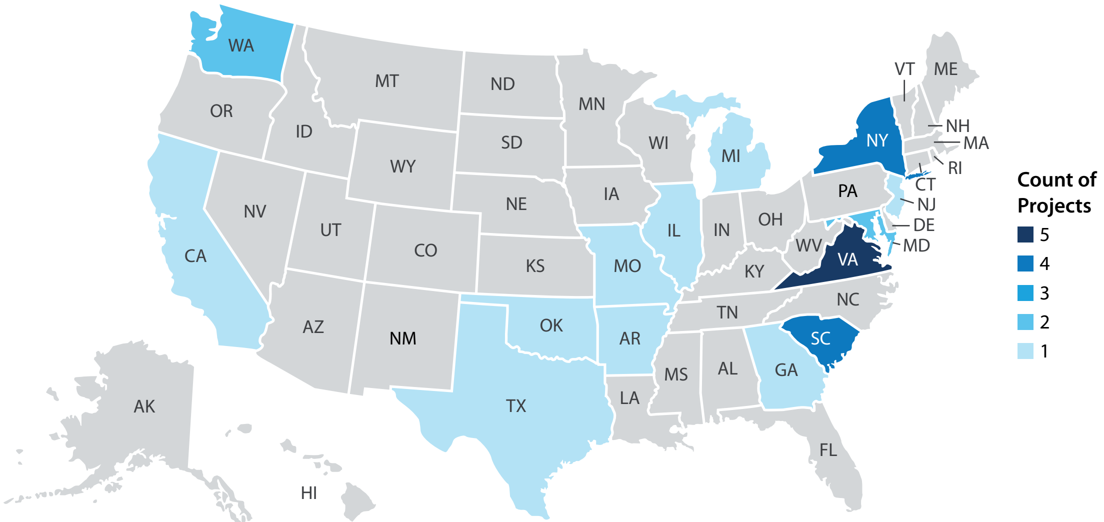

Figure 46. Awarded DOE ESPC IDIQ contract projects by location.

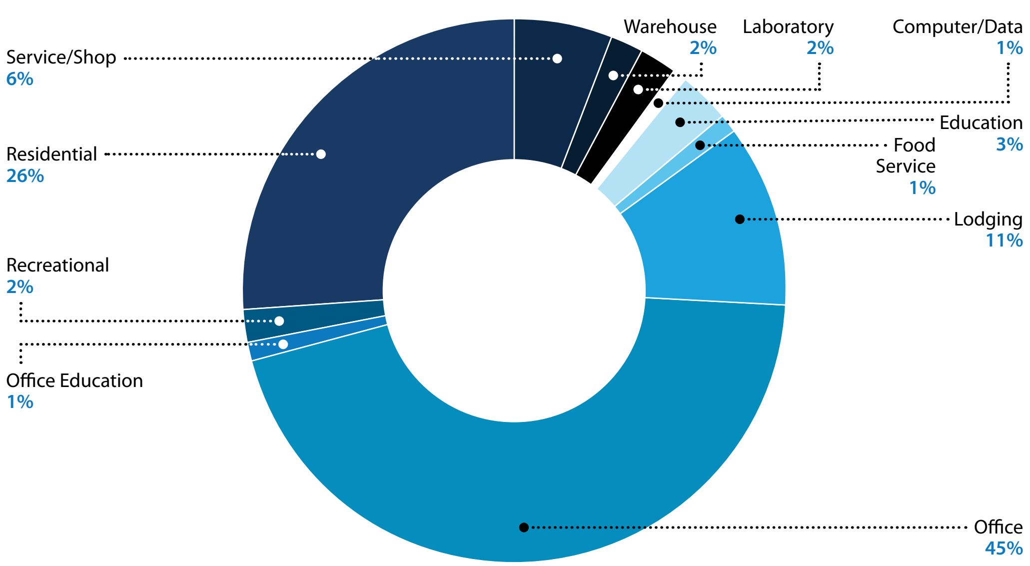

Figure 47. Percentage of total floor area by building type of GHP installations at federal facilities. *Figure from Shonder and Walker (2024).*

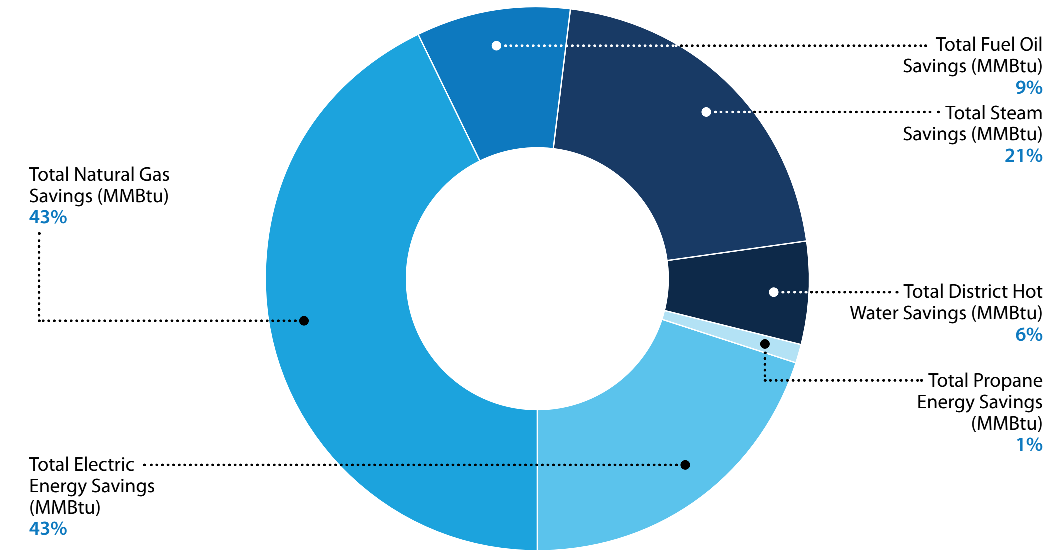

Figure 48. Breakout of cost savings from GHP energy conservation measures at federal facilities, including O&M, energy, and water use savings. *Figure from Shonder and Walker (2024).*

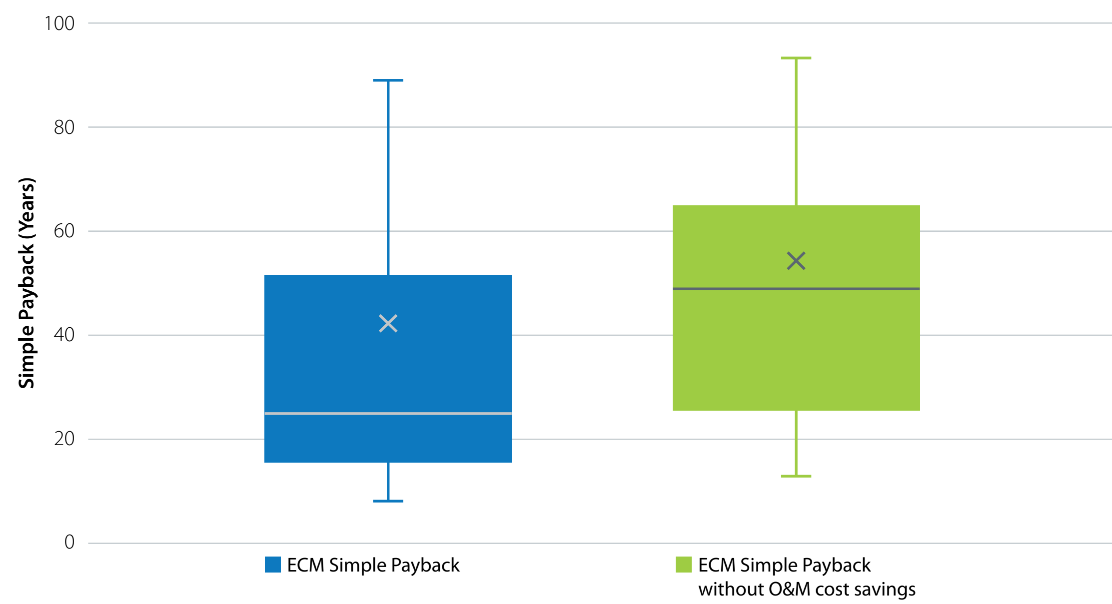

Figure 49. Distribution of GHP ECM simple payback as reported and with O&M cost savings removed.

6. Updates on Emerging Technologies and Applications

Several opportunities exist for geothermal expansion beyond well-known and characterized resources and applications. Some opportunities like superhot geothermal could exponentially increase the amount of thermal energy extracted from the subsurface. Non-thermal applications like the extraction of lithium from geothermal brines helps to consolidate and secure the U.S. supply of critical minerals. Hybridizing geothermal systems with other energy systems and underground thermal energy storage could increase plant efficiency and enhance grid reliability. Flexible operations within geothermal plants opens up revenue streams beyond traditional PPAs.

Photo from Mazama Energy

6.1 Superhot Geothermal

Superhot geothermal targets deeper and hotter resources compared to conventional systems. These reservoir conditions can exceed the critical temperature and pressure of pure water (i.e., 374°C and 221 bar), and can yield 5-10 times more energy per well (Cladouhos et al., 2018; Feng et al., 2021) and ~50% reduction in LCOE compared to conventional systems (Kiran et al., 2024). The average conversion efficiency of conventional geothermal power plants stands at ~12%, while plants with higher pressures and temperatures (coal, natural gas, nuclear) have efficiencies of 30%–40% (Zarrouk and Moon, 2014). This gap in efficiencies shows how superhot resources can boost geothermal well power output with competitive economics.

As of December 2025, there are no operational geothermal plants that produce electricity from superhot geothermal fluids in the United States. However, there has been increasing interest in advancing superhot geothermal technologies. For example, the DEEPEN (DE-risking Exploration in geothermal Plays in magmatic ENvironments) project, part of the transnational GEOTHERMICA consortium, focused on improving the likelihood of success when drilling for superhot resources in magmatic geothermal systems.[47] In Oregon, Mazama Energy is piloting a superhot EGS on the western flank of Newberry Volcano, with plans to drill two deep wells in 2025 and 2026 (DOE 2024b). In early 2025, ARPA-E launched the Stimulate Utilization of Plentiful Energy in Rocks through High-temperature Original Technologies (SUPERHOT) program that aims to provide $30 million in funding to unlock technical barriers to the development of superhot reservoirs (ARPA-E, 2025).

The Clean Air Task Force recently published several reports that provide a comprehensive gap analysis across key technology areas essential for the success of superhot projects (CATF, 2025). The Clean Air Task Force reports that the technology to enable commercial deployment of superhot geothermal is within reach, but a pressing need is for facilities to test equipment and methods at superhot conditions (CATF, 2025). Advancing the development of superhot geothermal resources may require multidisciplinary and cross-national collaboration to achieve these needs and de-risk technology.

6.2 Hybrid Geothermal Systems

A hybrid geothermal energy system is one that combines geothermal with another energy source to enhance efficiency and reliability (DiPippo, 2016). Geothermal is a beneficial resource to pair with, because its 24/7 reliability

[47] For more information, see https://www.geothermica.eu/project/deepen.

can balance non-dispatchable generation from wind and solar, as well as offer additional options for providing flexible generation and grid stability when combined with other technologies (Wendt et al., 2018).

For example, geothermal can be paired with concentrating solar-thermal power to provide baseload capacity and peaking power (McTigue, Simpson, et al., 2023). This configuration allows for flexible power generation, with solar thermal storage capabilities enhancing sustained high-power output during intermittent cloud cover during the day and at night (Wendt et al., 2018). This type of hybrid plant's LCOE could be 25%–50% lower than that of a PV array with battery storage, and up to 15% lower than a concentrating solar plant with thermal storage. In addition, from an NLR-led study, the combined thermal-energy-to-electricity-conversion efficiency for this hybrid system could be around 20% more than a standalone geothermal power cycle (McTigue et al., 2020). Solar thermal-geothermal hybridization could also result in a higher capacity factor compared to a standalone solar thermal system because geothermal compensates for periods of low solar irradiation (McTigue, Simpson, et al., 2023).

There are three recent examples in Nevada of hybridization or co-location with solar energy: (1) Ormat's Stillwater project with a 33-MWe geothermal plant, a 26-MWe solar PV plant, and a 2-MWe solar thermal plant (Power Technology, 2023), (2) Cyrq Energy's Patua project with a 30-MWe geothermal plant and a 10-MWe solar PV facility (Cyrq Energy, 2023), and (3) Ormat's Tungsten Mountain project with a 24-MWe geothermal plant and an 18-MWe solar PV facility (Richter, 2019).

6.3 Critical Mineral Extraction

Geothermal brines are formed as water becomes heated by geothermal activity and dissolves various minerals from surrounding rocks. The composition of geothermal brines is complex, often containing high concentrations of valuable minerals such as lithium, silica, manganese, and zinc (Neupane and Wendt, 2017). Domestic availability of such minerals is of particular interest due to their increasing demand in various high-tech industries. Cost-effectively extracting these critical minerals from geothermal brines could reduce U.S. reliance on imports and improve supply chain security.

Battery-grade lithium is one of the critical minerals that can be derived from geothermal brines. The latest resource assessment by the U.S. Geological Survey has revealed that the Smackover Formation brines in southern Arkansas contain 5.1 million to 19 million tons of lithium, equivalent to 35% to 136% of the 2023 U.S. lithium resource estimate (Knierim et al., 2024). The Salton Sea Geothermal Field in California, in addition, is a well-known potential resource for lithium extraction. In a DOE-funded project, Dobson et al. (2023) reported that geothermal brine production in the Salton Sea region has averaged over 120 million metric tons annually since 2004. The authors also estimated the total dissolved lithium resource in the well-characterized area to be 4.1 million metric tons of lithium carbonate equivalent, which could increase to 18 million metric tons with expanded assumptions on reservoir size and porosity (Dobson et al., 2023).

DOE recently selected seven national laboratory projects to study lithium extraction in Known Geothermal Resource Areas, including the Salton Sea region, the Smackover Formation in Louisiana and Arkansas, and the Paradox Basin in Utah (GTO, 2024c). In addition, several companies are developing commercial lithium extraction projects in the Salton Sea region, including Berkshire Hathaway Energy Renewables, EnergySource Minerals, and Controlled Thermal Resources (CTR). CTR's Hell's Kitchen project is the region's first operational commercial lithium extraction plant (Suzuki, 2025). The $1.85 billion CTR development includes a geothermal power plant integrated with a lithium production facility, which is expected to produce 25,000 metric tons of battery-grade lithium hydroxide monohydrate each year (Cariaga, 2024b). In July 2021, General Motors formed a strategic investment and commercial collaboration with CTR to secure local and low-cost lithium (NS Energy, 2024).

From an economics perspective, the high upfront capital costs associated with geothermal mineral extraction may pose a significant barrier to development. However, operational costs have been estimated to be within the range of hard rock lithium mining (Warren, 2021; Nagar et al., 2024). Building the necessary infrastructure and integrating extraction systems with geothermal power plants could maximize revenue, but the uncertainty around return on investment due to fluctuating market prices and supply chain instabilities may pose challenges. The future of geothermal mineral extraction is promising, but the technology must prove competitive in terms of efficiency, scalability, and cost-effectiveness to gain a foothold in the global minerals market.

6.4 Underground Thermal Energy Storage

Underground thermal energy storage refers to technologies that hold energy in the form of heat in the subsurface. Energy can be derived from a wide range of sources, such as the surplus electrical energy from power plants, as well as from solar thermal, biomass, nuclear, or industrial waste heat. This energy is then transferred to a variety of suitable underground formations and structures such as deep sedimentary basins, shallow aquifers, storage tanks, boreholes, and depleted oil and gas reservoirs. Geothermal energy has historically been seen as a baseload energy source, but the hybridization of geothermal with underground thermal energy storage unlocks its potential for energy storage, allowing for flexible dispatching and improving grid stability, or use in district-scale heating and cooling and industrial process heating (McTigue, Zhu, et al., 2023).

Underground thermal energy storage technologies are classified according to the types of storage media, loop type (open or closed), depths, and storage temperatures (Figure 50). Aquifer thermal energy storage, reservoir thermal energy storage, and geological thermal energy storage (GeoTES) are three prominent open-loop systems that have the potential to significantly address shortages in energy storage brought on by the influx of intermittent renewable energy sources to the U.S. electric grid.

From a market assessment perspective, development of reservoir thermal energy storage and aquifer thermal energy storage is centered in Europe, where nearly 2,500 aquifer thermal energy storage systems are currently operational (Fleuchaus et al., 2018). Nearly all of these are low-temperature (storage temperature <25°C) systems, with the exception of five high-temperature aquifer thermal energy storage systems (McLing et al., 2022; Vardon et al., 2024). There is one operational U.S.-based aquifer thermal energy

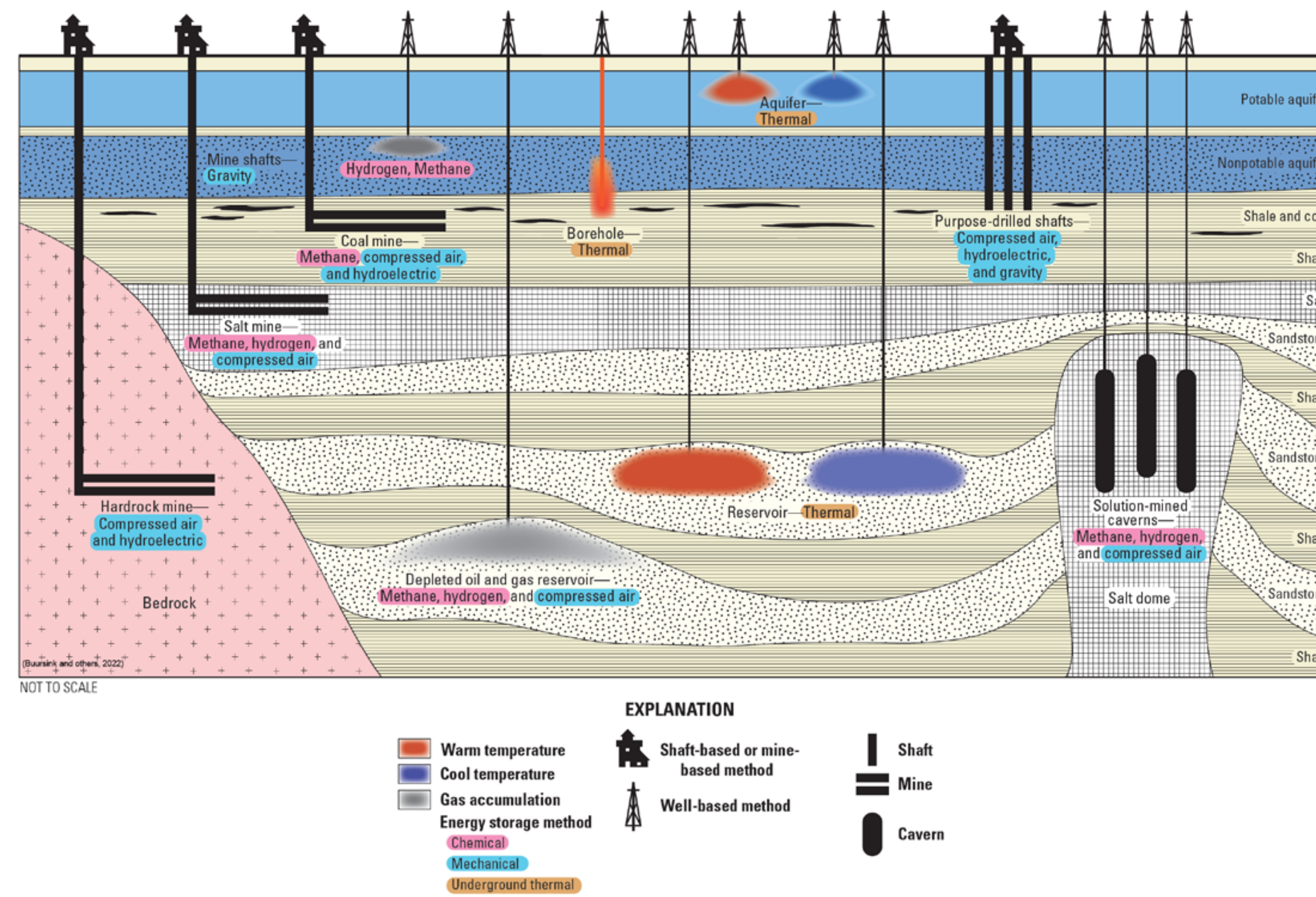

Figure 50. Illustration of the depth and geological settings of underground thermal energy storage technologies and their distinction from other energy storage technologies. *Figure from Buursink et al. (2023)*

storage project located at the Richard Stockton College in Galloway, New Jersey, which provides storage for a 2-MW district cooling system (Fleuchaus et al., 2018).

GeoTES is an emerging technology and there are currently no active plants. However, two GeoTES systems are in development in California and Texas. Premier Resource Management is working with NLR and a coalition of other national labs to design and develop a 10-MWe demonstration plant in California's San Joaquin Valley. The system will be heated by a 40–50-acre parabolic trough solar concentrator array that can either supply energy directly to a 10-MWe turbine or store for later use in the Antelope Hills oil field. Full development of this project features expansion to 408 MWe, requiring 321 total wells (Berger et al., 2023). Modeling by Akindipe et al. (2024) found this 10-MWe plant to have an LCOE between $0.112–0.223/kWh.

EarthBridge Energy, in partnership with NLR and other national labs, is designing the GeoBattery, a GeoTES system that acts as the subterranean storage for a Carnot battery (Murray, 2023). A MW-scale demonstration plant is planned at their site north of Houston, Texas. The Carnot battery-GeoTES system will take advantage of excess energy from wind, solar PV, or the grid, using it to simultaneously heat and cool geothermal brine using a heat pump. The brine will be stored in separate sections of a single shallow brackish aquifer. When energy is needed, both the hot and cold brine will be pumped to the surface to generate electricity using a heat engine. Modeling by Akindipe et al. (2024) found this Carnot battery-GeoTES system to have a levelized cost of storage of 0.258–0.294 $/kWh.

The main closed-loop underground thermal energy storage system in operation in the United States is borehole thermal energy storage (BTES). BTES technologies store heat or cold in underground shallow vertical wells (or pipes) isolated from adjoining subsurface formations by multiple insulating barriers. A notable installation is the BTES system in the Marine Corps Logistics Base in Albany, Georgia. The first system installed in 2015 consists of 306 wells, 210 ft deep, arranged within multiple concentric thermal zones (Hammock and Sullens, 2017). The BTES stores cold from adiabatic dry coolers in the winter and discharges in the peak summer months for cooling a 168,000 square foot building. Three other BTES were installed in 2019, serving six other buildings at the base (Hammock and Caves, 2021).

Underground thermal energy storage technologies can be economically favorable for large-scale, long-term energy storage. For open systems, the cost of accessing the subsurface reservoir is dominated by the exploration cost, but once discovered, the maintenance cost of the reservoir is minimal over its lifetime (Sharan et al., 2021). Furthermore, the marginal cost of adding energy capacity is effectively zero so long as the reservoir volume is large enough. While surface-based energy storage options suffer from high maintenance and expansion costs, underground thermal energy storage technologies are well suited for large-scale, long-term development.

6.5 Geologic Hydrogen

Hydrogen gas naturally seeps from geologic systems in deep ocean ridges and some onshore sites and has been found to be one of the constituents in gases from hydrothermal systems. This could lead to another opportunity for geothermal resources, if hydrogen can be sourced from the geothermal brines used in power production (Combaudon et al., 2022). Apart from naturally occurring geologic hydrogen, subsurface features characterized by geothermal heat anomalies and suitable iron-rich ultramafic and mafic minerals could be potential source rocks for stimulated geologic hydrogen. From a technology perspective, stimulated geologic hydrogen can be advanced through learnings from EGS technology development where hydraulic stimulation has been proven to create permeable reservoirs and suitable near-wellbore conditions for fluid flow and heat transfer. The current annual hydrogen production in the United States stands at 10 million metric tons (DOE, 2023) and the in-country demand for hydrogen is anticipated to rise to 78 to 93 million metric tons annually by 2050 (Gulli et al., 2024). Geologic hydrogen could potentially become a hydrogen supply source to meet this growing demand from energy-intensive sectors like chemical and industrial processes and heavy-duty transportation, and in fuel cells for electric vehicles and power generation. On another front, geothermal energy could also be utilized to produce hydrogen from other pathways (e.g., electrolysis and biomass pyrolysis). Shah et al. (2022) reviewed surface hydrogen production using geothermal heat and power, including assessing ways to solve potential fuel shortages using geothermal-integrated hydrogen production systems.

6.6 Sedimentary Geothermal Resources

Sedimentary geothermal resources present the possibility of leveraging existing data and technologies from the oil and gas industry to unlock substantial geothermal energy potential (Johnston et al., 2020). These resources are characterized by reservoirs with sufficient permeability and porosity to allow for the flow of hot water or steam for geothermal energy production. The temperature of these reservoirs can vary, with some having the potential to support power generation, while others are more suited for direct-use applications such as district heating. The United States has a significant potential for sedimentary geothermal resources (Porro et al., 2012). Recent advancements in next-generation geothermal technology expands the resource potential of sedimentary geothermal resources to formations with low permeability.

The Salton Sea Known Geothermal Resource Area in California's Imperial Valley is the foremost sedimentary geothermal resource in the United States. Current geothermal power installed capacity is around 200 MWe (Appendix B). Beyond the Salton Sea basin, other basins, including the Williston Basin (North Dakota, Montana, and South Dakota); the Great Basin carbonate and alluvial aquifer system (Nevada and Utah); the Denver, Piceance, and Raton Basins (Colorado); and the Gulf Coast Basin (Texas) have been considered for sedimentary geothermal (Gelman and Burns, 2025; Johnston et al., 2020).

Additionally, the integration of GHPs with sedimentary geothermal resources has shown promise for efficient heating and cooling of buildings (J. W. Lund and Toth, 2021). Davalos-Elizondo et al. (2023a) identified sedimentary basins that can be explored further for low-temperature geothermal favorability analysis. The findings from this review guided the selection of priority areas for further exploration and development, and ongoing work on the geothermal play fairway analysis will provide more insight into the Denver Basin's potential for geothermal development (Davalos-Elizondo et al., 2023).

6.7 Co-Production of Geothermal Energy from Oil and Gas Reservoirs

Co-production of geothermal energy from oil and gas reservoirs is an innovative approach that harnesses the thermal energy present in the fluids produced during oil and gas extraction. This process allows for the simultaneous production of hydrocarbons and geothermal energy, offering a cost-effective and efficient way to tap into geothermal resources. This geothermal energy can be used for electricity generation or direct-use applications, such as heating buildings or industrial processes (GTO, 2010). Co-production could involve geothermal-extraction-only applications, especially in uneconomical wells with overbearingly high water concentrations relative to hydrocarbons. Wells could be used as is, re-completed, or deepened to access resources with higher thermal gradients and water concentrations (Robins et al., 2021).

NLR and Gradient Geothermal researchers inspect a production well at Blackburn field in Nevada. *Photo by Koenraad Beckers, National Laboratory of the Rockies*

Co-production has been demonstrated within several projects in the U.S., starting with the Rocky Mountain Oilfield Testing Center project in Wyoming, which achieved the first successful generation of electricity from an oil and gas producing well using a 250-kW ORC unit (GTO, 2010). More recently, in 2022, DOE awarded $8.4 million to four projects in its Wells of Opportunity initiative to repurpose inactive or idle hydrocarbon wells for geothermal energy use in California (ICE Thermal Harvesting), Nevada (Gradient Geothermal), Oklahoma (University of Oklahoma), and Texas (Geothermix) (GTO, 2025c). The awarded projects under the Wells of Opportunity initiative have recorded several successes. The first permit for geothermal energy production from oil and gas wells in Oklahoma was granted to the University of Oklahoma. Geothermix demonstrated the successful construction and lab scale testing of novel thermoelectric generation cells for harvesting thermal energy from oil and gas to generate electricity (Miller, 2023). Gradient Geothermal (formerly Transitional Energy) has pilot tested and validated

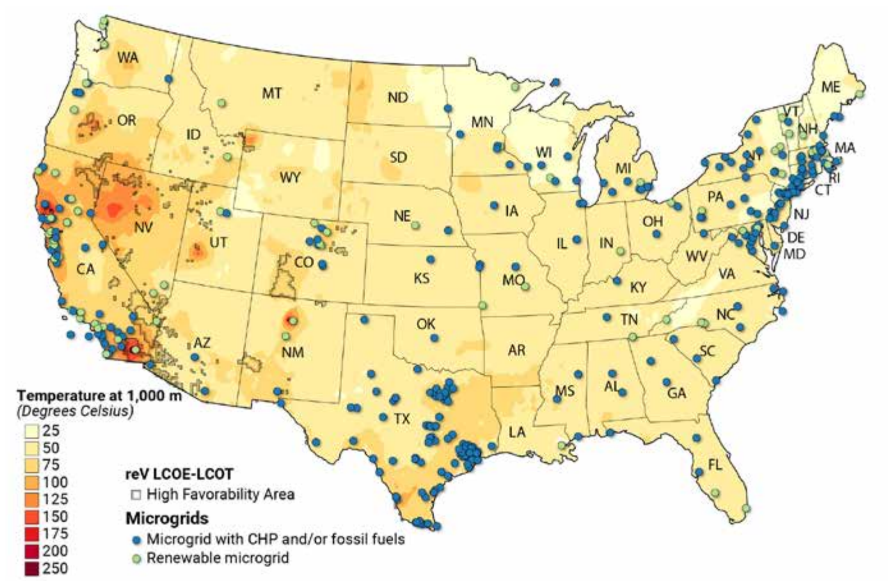

Figure 51. Potential regions for geothermal microgrid development (Witter et al., 2024), existing microgrids (ORNL, 2024), and subsurface temperature in the conterminous United States (Batir et al., 2016).

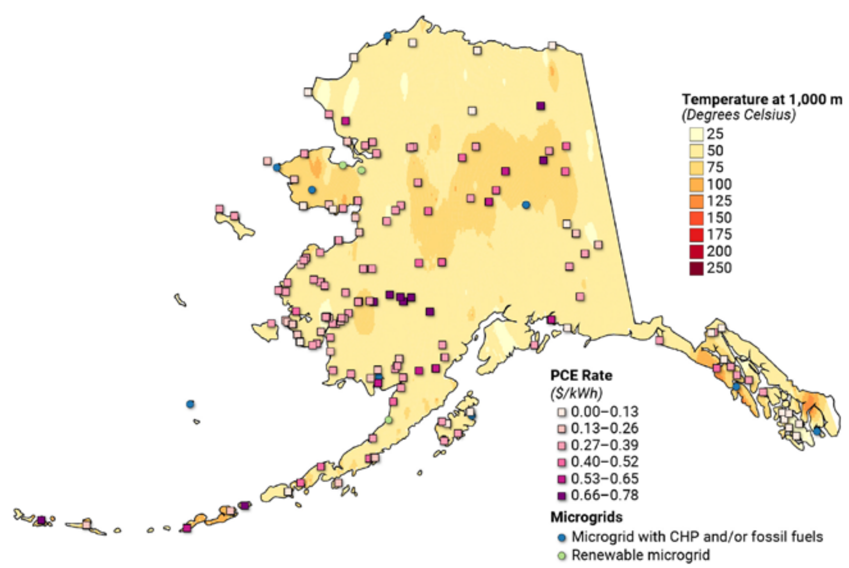

Figure 52. Existing microgrids (ORNL, 2024) and play fairway analysis in Alaska (Davalos-Elizondo et al., forthcoming).

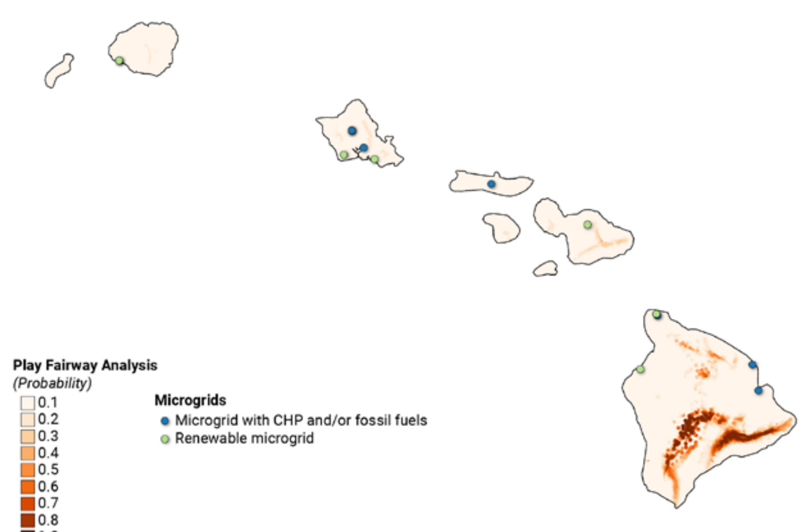

Figure 53. Existing microgrids (ORNL, 2024) and play fairway analysis in Hawai'i (Lautze et al., 2018).

the viability of geothermal power generation potential from a well in the Blackburn oil field in Nevada, and is developing a commercial co-production pilot project in North Dakota's Williston Basin (Larson, 2025).

Some existing oil and gas workforce, skills, and supply chains are largely transferable to the geothermal industry. To leverage this oil and gas industry knowledge, technology, and experience, DOE inaugurated the Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE) initiative in September 2024 (GTO, 2024d). The GEODE initiative project, led by Project Innerspace under a $10 million DOE award, is anticipated to develop a consortium to foster inter-sector synergy and tackle barriers to geothermal deployment with active involvement of both geothermal and oil and gas workers, communities, and other stakeholders (GTO, 2024d).

6.8 Geothermal Microgrids

A microgrid is a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid (Ton and Smith, 2012). Microgrids have been recognized as a key technology in fostering resilience, stability, and security for the electric grid. Their ability to operate independently of the larger grid using decentralized, local generation means they are less vulnerable to disruptions to the power system such as cyberattacks and natural disasters.

Only one microgrid to date in the U.S. has incorporated geothermal as an energy source. Chena Hot Springs in Alaska developed 680 kW of geothermal capacity, working in parallel with diesel generators. By taking advantage of near-freezing proximate water sources and a binary power cycle, the site has been able to use the lowest-temperature (71°C or 160°F) geothermal resource for power in the world, displacing well over 150,000 gallons of diesel annually, while heating pools and the greenhouse (Arctic Council Working Group, 2025). Despite the current lack of installation, there is potential for geothermal microgrids development in the United States Kolker (2008) explored the potential for small-scale geothermal development in 13 remote Alaskan communities. When all externalities were factored in—energy subsidy costs, heating fuel savings, benefits from greenhouses, and avoided fuel spills—geothermal was found to be more cost-effective in 8–12 of the communities, depending on the policy environment.

Witter et al. (2024) analyzed and overlayed multiple datasets to identify regions best suited for geothermal microgrids across the contiguous United States, Alaska, and Hawai'i, seen in Figure 51, Figure 52, and Figure 53. High favorability regions in Figure 52 and Figure 53 are areas where geothermal development is relatively low-cost (first quartile of LCOE) but connecting to the national grid is more expensive (third quartile of levelized cost of transmission [LCOT]). Blue dots mark existing microgrids with combined heat and power and/or fossil fuel generation. Targeting geothermal development in the high favorability areas could provide reliable off-grid power and enhance grid stability and security.

6.9 Flexible and Dispatchable Geothermal Power

For many decades, geothermal power plants have supplied baseload electricity to the U.S. grid. However, accelerated deployment of intermittent energy (e.g., solar and wind) has led to a growing market for flexible and dispatchable geothermal. Geothermal offers firm, flexible power generation with a high capacity factor and minimal land use. Flexible geothermal operation can provide ancillary services to the grid, such as frequency and voltage regulation, load following, grid support during peak periods, spinning and non-spinning reserve, and supplemental reserve. Despite these benefits, its deployment has been less compared with other renewables. Bolinger et al. (2023) explain one reason for this difference by examining the empirical price data from PPAs and wholesale energy and capacity markets. They found that from a market perspective, geothermal has historically offered less net value (i.e., wholesale market value minus PPA price) compared to solar and wind resources. Mai et al. (2022) highlighted the importance of early deployment of non-variable technologies like geothermal for reliable baseload generation. They also emphasize the potential of long-term storage technologies in supporting the future grid.

Several modeling projects over the past few years have shed light on the impact that flexible geothermal can have in the United States. Millstein et al. (2020) finds that flexible dispatching in geothermal generation could increase its value by up to $4/MWh in California by curtailing operations during low-price periods and boosting output during high-price hours. Ricks et al. (2022) conducted capacity expansion modeling to estimate the value of flexible EGS plant operation enhanced by in-reservoir geomechanical storage. The authors reported up to 60% energy value improvements compared to baseload plants operating under identical conditions (Ricks et al., 2022). By accounting for storage in their capacity expansion models for EGS, Ricks et al. (2024) also determined that flexibility increases the EGS value by up to 37% compared to baseload operations. Aljubran and Horne (2025) reported an average 10% improvement in the value of CH to the grid nationwide through flexible dispatch. Aljubran and Horne (2024b) found nationwide EGS LCOE improved by about 25% by switching to flexible operations, because such operations yield greater power generation during the early life of the project.

An early precedent for this dispatchability approach is the Puna geothermal field run by Ormat Technologies, Inc. in Hawai'i (Nordquist et al., 2013). There, 8 MWe out of the 38 MWe total plant nameplate capacity is dedicated for flexible operations achieved via either binary or steam turbine bypass across integrated combined cycle units with ramp up and down capabilities and 3-MWe spinning reserves (Nordquist et al., 2013; Matek, 2015). Another example of flexible geothermal dispatch is in California at The Geysers, where multiple power plants provide some load-following services. Farison et al. (2022) revealed that power plants at The Geysers can provide increased flexible geothermal power (beyond current operations) within the limits of contracted PPAs. Calpine recently installed 4-hour duration lithium-ion battery energy storage systems at two geothermal facilities at The Geysers—Bear Canyon and West Ford Flat systems, with 13 MWe and 25 MWe power capacity, respectively (Calpine 2025a, 2025b).

Another potential pathway for flexible geothermal is long-duration in-reservoir energy storage at EGS locations. This has been pursued by Fervo Energy and funded by ARPA-E (ARPA-E, 2022). Storage could be in the form of pressure-driven and/or thermal energy storage. In pressure-based storage, higher injection rates compared to production rates cause pressure buildup within the confined fractures of the EGS reservoir (Ricks et al., 2022; Simpkins et al., 2023). This extra energy can be dispatched for short (e.g., frequency response) or long durations (e.g., hourly load-following applications). This behavior was first observed during long-term flow tests in the Fenton Hill EGS project (D. Brown et al., 2012). Sage Geosystems has demonstrated the in-reservoir energy storage technology, called EarthStore. Quidnet energy is another company actively developing this technology and has ongoing projects in the United States and Canada (Quidnet Energy, 2022; Schmidt et al., 2023).

The capabilities created through flexibility and storage integration can lead to enhanced grid resiliency and reliability. Additionally, flexible geothermal power could serve deferrable loads such as mineral extraction processing, hydrogen production, computational mining, or cloud computing, which may further enhance its value.

6.10 Carbon Dioxide Utilization in Geothermal Power Systems

Carbon dioxide (CO_2) utilization in geothermal power systems leverages the unique properties of CO_2 to enhance geothermal power generation. The application of CO_2 in geothermal systems is primarily focused on three innovative technologies: CO_2 as a working fluid in power conversion cycles and subsurface heat extraction, CO_2 in closed-loop systems (introduced in Section 3.6), and CO_2 plume geothermal technology.

CO_2 has been proposed as a working fluid for heat-to-power conversion cycles and subsurface circulation fluid for heat extraction. Using CO_2 as a working fluid in binary cycle power plants offers advantages like high thermal efficiency and compact equipment, making it a promising option for low- to medium-temperature heat recovery applications (Chowdhury and Ehsan, 2023). CO_2 is also a promising geothermal heat extraction fluid because of its low viscosity, high thermal expansivity, and ability to reduce mineral precipitation, leading to efficient heat extraction and reduced energy consumption in geothermal systems (Esteves et al., 2019).

Southwest Research Institute and GTI Energy are building a first-of-a-kind 10-MWe supercritical CO_2 Brayton cycle demonstration project co-funded by DOE (GTI Energy, 2024; Southwest Research Institute, 2025). Supercritical CO_2 Brayton cycles convert thermal energy from higher temperature resources, such as those encountered in superhot geothermal systems, to power. They are generally more efficient (+10%) than conventional steam Rankine cycles (Southwest Research Institute, 2025). Challenges with using supercritical CO_2 in power conversion cycles include CO_2 supercriticality maintenance (above 31°C and 74 bar), potential flow instabilities, material selection to counterbalance corrosion, and potential CO_2 leakage from plant equipment.

The use of supercritical CO_2 as a heat transfer fluid within the wellbore of closed-loop systems has been implemented at the pilot scale. GreenFire Energy carried out pilot CLG tests in a flowing hydrothermal well at the Coso Geothermal Field. The integration of CO_2 into CLG systems has the potential to significantly expand the geothermal market by making lower-temperature reservoirs economically viable and enhancing the output of existing plants. Beckers et al. (2022) modeled U-loop CLG designs and observed that, at lower temperatures (150°–200°C), a design that uses supercritical CO_2 as both the circulating heat transfer fluid in the U-loop and the working fluid in the power cycle generated close to two times the power output of a water-based U-loop design connected to an organic Rankine cycle (Beckers et al. 2022). Although capital costs for such designs could be higher than non-CO_2-based systems, the operational costs could be lower over time due to higher efficiency and lower maintenance requirements. Economies of scale and technological advancements are expected to reduce costs further. Studies suggest that the LCOE for CO_2-based CLG systems could become competitive with traditional geothermal systems as the technology matures (White et al., 2024).

CO_2 plume geothermal technology represents an innovative approach to enhancing geothermal energy production. The core mechanism of CO_2 plume geothermal involves the injection of supercritical CO_2 into geothermal formations, which then disperses to form a plume that effectively absorbs heat from the surrounding rock. CO_2's properties (e.g., higher density and lower viscosity) at supercritical conditions make it efficient at transporting heat compared to water, facilitating broader operational ranges, and accessing heat from deeper geological formations (Randolph and Saar, 2011). Therefore, CO_2 plume geothermal may enhance geothermal power generation. Technical challenges with this technology include unwanted chemical reactions with host rocks, and wellbore scaling and in-reservoir CO_2 losses and leakage, especially in fractured systems. The technology also requires precise management of CO_2 injection to optimize plume development and ensure efficient heat transfer. The economic viability of CO_2 plume geothermal systems depends on advancements in well construction and CO_2 technologies, as well as regulatory support.

7. Conclusion

This report captures the current state of the U.S. geothermal market, technologies, and use cases across spatial and temperature scales—from shallow ambient-temperature GHP systems to deep superhot rock geothermal systems. The goal is to inform and update geothermal stakeholders—including energy developers, government agencies, the oil and gas industry, policymakers, non-governmental organizations, Tribal entities, local communities, and others—about geothermal energy's unique value proposition and potential to grow. Although the geothermal energy industry has generally experienced steady growth in the number of installations and capacities, technical and non-technical hurdles remain. Concerted efforts to address these hurdles since the 2021 Geothermal Market Report have yielded gains, especially in the power sector where next-generation systems are breaking technical barriers to resource availability and capacity expansion.

Photo by Eric Larson, Flash Point SLC

7.1 Geothermal Power Sector

The geothermal power sector has experienced steady growth in installed capacity and project development. As of January 2025, geothermal power installed nameplate capacity is at 3.97 GWe, an 8% increase from 3.67 GWe in 2020. New power plants with binary cycles are gradually replacing older steam-cycle-based power plants and account for 35% of total plant capacity (up from 32% in 2020). Geothermal power plants are almost entirely concentrated in the western United States, but numerous efforts are underway to unlock opportunities beyond traditional geothermal power operating regions.

The number of geothermal power projects under development has remained stable when comparing data from the same companies that still exist today. Based on data compiled in this report, 26 new geothermal PPAs have been signed since the previous Market Report, which together promise over 1,640 MWe of new capacity. Most of the new projects are planned to be developed in California and Nevada, and range in generation size from 2 MWe to 320 MWe. The surge in PPAs, especially from California, is largely due to the procurement order by the CPUC, which tasked load-serving entities in the state to acquire 1 GWe of firm, high capacity factor electricity by 2026.

Multiple projects are demonstrating and deploying next-generation geothermal technologies that can expand the use of geothermal nationwide. The Utah FORGE project has closed major technology gaps in hard rock drilling and EGS stimulation risks. In 2023, Fervo Energy installed first-of-a-kind commercial-scale EGS well pairs, proving the possibility of commercially viable well production flow rates. Fervo has also started developing an expected 500-MWe EGS power plant in Beaver County, Utah, and Eavor has drilled the first high-temperature multilateral geothermal well in New Mexico to a true vertical depth of 18,000 ft and rock temperature of 250°C.

Geothermal capital and installation costs vary by resource type and surface power conversion technology. The LCOE for conventional hydrothermal systems has remained around $63–74/MWh for flash and $90–110/MWh for binary plants. At these levels, geothermal operators are still market-competitive owing to increasing PPA prices for firm, high capacity factor and reliable geothermal electricity. The LCOE for EGS is also declining due to drilling, well completion, and productivity de-risking efforts.

As of December 2024, the Inflation Reduction Act provided up to 30% recovery of investments for geothermal power projects via an ITC. On July 4, 2025, the ITC was updated and extended through 2036 with a phase down beginning in 2034 and repeal in 2036 (H.R.1, 2025). In addition, 29 U.S. states have incentive policies for geothermal power including, grants, rebates, tax incentives, and other financial incentives. A total of 17 states and D.C. have policies that encourage geothermal electricity production, and 42 states and D.C. have existing regulatory policies that relate to geothermal power.

7.2 Geothermal Heating and Cooling Sector

7.2.1 Geothermal Heat Pumps

GHPs have become an appealing option for consumers seeking to reduce energy consumption and increase efficiency. The ability to provide substantial energy savings and reliable year-round comfort makes GHPs particularly attractive to homeowners, businesses, institutions, and energy utilities. With over a million installations across the country, the GHP market is mature and plays a major role in enabling energy-efficient distributed energy systems. Historical data have revealed that closed-loop GHP systems are the most installed due to their efficiency and adaptability. Open-loop GHP systems have maintained a steady but smaller share of the market, possibly because of their geographic limitations or more stringent environmental regulations on surface land use. Overall, GHP residential equipment sales have contracted from a peak in 2007 and have entered a stable phase.

Based on extrapolations from the 2020 RECS and 2018 CBECS data, an estimated 1.27 million residential housing units and 27,300 commercial buildings across the United States have GHP installations. These estimations suggested that Florida, North Carolina, and Tennessee have the highest number of residential housing units with GHPs. In the commercial buildings sector, the West North Central region has the highest number of commercial buildings with GHPs, followed by the Mountain and South Atlantic regions. The estimations are not ground truths, as the two nationwide surveys (RECS and CBECCS) have limited representativeness, and would need to be verified with additional data collection.

GHP demand is potentially expected to grow as building efficiency practices and regulations become more common and with the proliferation of GHP-based TENs. Deploying GHPs at mass scale (~70% of U.S. building stock) could drastically reduce peak load and reduce the need for new generation and transmission infrastructure.

Geothermal district heating and cooling can enable energy-efficient GHP networks across multiple building types. These installations have been deployed in college campuses, large building complexes, and at the utility scale. A primary driver for the proliferation of geothermal district heating and cooling systems on college campuses is the motivation to achieve defined energy efficiency goals. Energy utilities are developing TEN pilot projects and states like California, Colorado, Maryland, Massachusetts, Minnesota, New York, Vermont, and Washington have enacted regulations and programs for utility-owned TENs. Government policies and incentives have supported GHP adoption, particularly in addressing the challenge of high upfront GHP installation costs. Federal, state, and local programs offering tax credits and rebates have eased the financial burden of GHP installations, making them more attainable. Initiatives like the federal ITC and state-level efficiency incentives provide support to offset upfront costs. Technological advancements have also moved the GHP market forward by improving system performance. As GHP deployment grows, economies of scale could reduce the costs of equipment and installation, helping make GHPs more competitive with other HVAC options.

Specialized knowledge is required for both HVAC and borehole installation for GHP systems, and not all HVAC professionals are equipped to handle these projects. This can make it difficult for consumers to find qualified installers, especially in regions where GHP installations are less common. Regulatory and permitting challenges can also complicate installations in some jurisdictions.

Despite these challenges, there is still potential for cost reductions. Demand-induced competition among manufacturers, advancements in loop designs, faster drilling rates, and economies of scale via district-scale networked geothermal systems are likely to introduce learnings that may reduce costs. Continued government support and innovative financing mechanisms, especially for residential customers, could help overcome the economic barriers that currently limit GHP adoption, positioning the technology for even greater growth in the years ahead.

7.2.2 Geothermal Direct Use Sector

A key benefit of GDU is its high efficiency; because the heat is used without the need for energy conversion, there are negligible system losses. Based on the data compiled in this report, GDU in resorts and pools accounts for the largest (i.e., 59%) market share in terms of number of installations, followed by space heating, aquaculture, greenhouse, and district heating applications. California has the most GDU installations in the United States, 70% of which are resorts and pools, followed by Idaho, which houses the nation's oldest geothermal district-heating installation. No new GDU district heating systems have been installed since 2017; however, in 2022, Cornell University drilled a deep geothermal district heating observation well that will provide important data for drilling a future injection-production well pair.

Advancements in technology and supportive policy frameworks could drive future growth in the GDU market. As of June 2025, there are 17 states with incentive policies and eight states with existing regulatory policies for GDU. GDU projects eligible for the ITC (Section 48E) prior to December 2024, built between 2021 and 2025 were eligible for a base tax credit of 30% plus potential bonuses, including 10% bonuses respectively for meeting specific manufacturing and location requirements. Uses for GDU are broadening as technology innovations make the systems more versatile. As of July 4, 2025, GDU projects constructed by 2033 are still eligible for the ITC through 2034.

7.3 Future Work

Periodic updates to the content and data compiled in this report can keep the geothermal sector and interested stakeholders updated on geothermal market trends and opportunities. Additional topics that may warrant future consideration include:

- Updates on the progress of the emerging technologies discussed in the report and those that have not yet been identified
- Comprehensive market assessment of TENs, especially for utility-owned developments
- Market updates of geothermal co-location for data centers, DoD geothermal development, and state-level geothermal-specific procurement calls
- Quantitative analysis of the resilience and/or national security benefits of geothermal power, storage, and heating and cooling
- Assessments of the growing overlaps and synergies between geothermal resources and other energy, fuels, and materials sectors, including geologic hydrogen and critical minerals.

Photo from Montana State University

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Appendix A. 2023 Geothermal Rising Industry Survey

Note: This appendix includes the survey text that was sent out to geothermal industry participants in December 2023. NLR is referred to by its previous name, NREL.

Instructions

Dear 2025 Geothermal Market Report Participant,

This excel file lists our (NREL and Geothermal Rising's) current knowledge of your company's developing and existing projects. We will use this information in our 2025 US Geothermal Market Report and we ask you to verify/confirm the information we have provided.

1. For clarification, the first section, "Definitions," provides terms and definitions relevant to different types of geothermal development projects.
2. The following sheets contain several templates with the information we collected about your current project(s). This information is gathered from publicly available information and past survey responses. We ask that you double check this information and please fill in the blanks where information is missing.
3. If your organization has developing projects that are not included in this excel file please add additional sheets for those projects.
4. We (NREL and Geothermal Rising) will not include specific information or proprietary information regarding your projects in the 2025 Report and will keep this information confidential. It is left to your organization to confirm the information we currently have on record.
5. Don't hesitate to reach out to us if you have any comments, questions, or concerns. Dayo Akindipe can be reached at dayo.akindipe@nrel.gov or by phone at (303) 275-4268. Anine Pederson can be reached at anine@geothermal.org or by phone at (254) 406-5458.

Thank you and we look forward to working with you,

Dayo Akindipe, Research Scientist - Subsurface Energy Systems, NREL and Anine Pedersen, Director of Science and External Affairs, Geothermal Rising (Project PIs)

Definitions

Geothermal Resource Types

Conventional Hydrothermal (Unproduced Resource, CH Unproduced): The development of a geothermal resource where levels of geothermal reservoir temperature and reservoir flow capacity are naturally sufficient to produce electricity and where development of the geothermal reservoir has not previously occurred to the extent that it supported the operation of geothermal power plant(s).

Conventional Hydrothermal (Produced Resource, CH Produced): The development of a geothermal resource where levels of geothermal reservoir temperature and reservoir flow capacity are naturally sufficient to produce electricity and where development of the geothermal reservoir has previously occurred to the extent that it currently supports or has supported the operation of geothermal power plant(s).

Conventional Hydrothermal Expansion (CH Expansion): The expansion of an existing geothermal power plant and its associated drilled area so as to increase the level of power that the power plant produces.

Geothermal Energy and Hydrocarbon Co-production (Co-production): The utilization of produced fluids resulting from oil and/or gas-field development for the production of geothermal power.

Enhanced Geothermal Systems (EGS): The development of a geothermal system where the natural flow capacity of the system reservoir is not sufficient to support adequate electric or thermal power production but where hydraulic stimulation of the system can enable production at a commercial level.

Advanced Geothermal Systems (AGS): The development or expansion of a geothermal system to enable the circulation of a working fluid in a subsurface tubular system without direct contact with the reservoir to bring heat to the surface for power generation. These include closed-loop and other forms of downhole heat exchangers.

Geothermal Capacity Types

Generator nameplate capacity (installed): The maximum rated output of a generator, prime mover, or other electric power production equipment under specific conditions designated by the manufacturer. Installed generator nameplate capacity is commonly expressed in megawatts (MW) and is usually indicated on a nameplate physically attached to the generator.

Summer capacity (installed): The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, as demonstrated by a multi-hour test, at the time of summer peak demand (period of June 1 through September 30). This output reflects a reduction in capacity due to electricity use for station service or auxiliaries.

Winter capacity (installed): The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, as demonstrated by a multi-hour test, at the time of peak winter demand (period of December 1 through February 28). This output reflects a reduction in capacity due to electricity use for station service or auxiliaries.

Existing Capacity

Instructions

Please double check this information and please fill in the blanks where information is missing

Please Return this Survey by Close of Business **Wednesday, January 31st, 2024**

Operating Facilities Basic Information						
Field Name	Plant Name	Nameplate Capacity (MW)	Summer Capacity (MW)	Winter Capacity (MW)	Net Generation (MWh)	Year Completed

Operating Facilities Basic Information (continued)					
Decommissioned? Y/N	Year Decommissioned	Turbine Type	Plant Type	Power only or CHP?	Additional Remarks

Total company employees:	

Notes

Nameplate capacity:
The maximum rated output of a generator, prime mover, or other electric power production equipment under specific conditions designated by the manufacturer, indicated on a nameplate physically attached to the generator.

Installed generator nameplate capacity is commonly expressed in megawatts (MW) and is usually indicated on a nameplate physically attached to the generator.

Summer Capacity:
The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, as demonstrated by a multi-hour test, at the time of summer peak demand (period of June 1 through September 30).

This output reflects a reduction in capacity due to electricity use for station service or auxiliaries.

Winter Capacity:
The maximum output, commonly expressed in megawatts (MW), that generating equipment can supply to system load, as demonstrated by a multi-hour test, at the time of peak winter demand (period of December 1 through February 28).

This output reflects a reduction in capacity due to electricity use for station service or auxiliaries.

Net Generation:
The amount of gross generation less the electrical energy consumed at the generating station(s) for station service or auxiliaries.

Note: Electricity required for pumping at pumped-storage plants is regarded as electricity for station service and is deducted from gross generation.

Plant Type:
e.g. -- Dry Steam, Binary, Single Flash, Double Flash, Co-production, EGS, Closed loop

Developing Project Information

Basic Information

Project Name
Developer
Estimated Nameplate Capacity (MW)
Estimated Resource Capacity (MW)
Project Type *(see Project Type Definitions)*
Power Plant Type *(Binary, Single, Double, or Triple Flash, Dry Steam, Closed Loop, Other)*
Estimated Year of Completion or Year Completed
Location (State, County)
Project Phase *I, II, III, IV (See Below) or Prospect*
Estimated Date to reach the next Phase?

Phase I Project

Resource Development: at least two of the following Resource Development criteria must be met.

- ☐ Literature Survey Complete
- ☐ Geologic Mapping Completed, Geophysical and Geochemical Sites Identified
- ☐ Geochemical and Geophysical Surveys in Progress

Transmission Development: all of the following Transmission Development criteria must be met.

- ☐ Internal Transmission Analysis Complete

External to Resource Development: all of the following criteria must be met.

- ☐ Land or Lease Acquired
- ☐ Permitting Process for Exploration Drilling (Temperature Gradient Hole and/or Slimholes) Underway

Phase II Project

Resource Development: at least one of the following Resource Development criteria must be met.

- ☐ Temperature Gradient Holes Drilled
- ☐ Slim Hole Drilled
- ☐ One Full Size Discovery Well Drilled

Transmission Development: at least one of the following Transmission Development criteria must be met.

- ☐ Interconnection Application Submitted and Queue Position Established
- ☐ Transmission Feasibility Studies Underway

External to Resource Development: at least one of the following External to Resource Development criteria must be met.

- ☐ Permit for Slimhole Drilling Applied for or Approved
- ☐ Permit for Production Well Drilling Submitted
- ☐ Permit for Production Well Drilling Approved

Phase III Project

Resource Development: at least two of the following Resource Development criteria must be met.

- ☐ At Least One Full Size Production Well Drilled and Operational
- ☐ At Least One Full Size Injection Well Drilled and Operational
- ☐ Reservoir Characterization Completed and Sustainable Reservoir Capacity Determined

Transmission Development: at least two of the following Transmission Development criteria must be met.

- ☐ Interconnection Feasibility Study Complete
- ☐ System Impact Study (SIS) Underway or Complete
- ☐ Interconnection Facility Study Underway
- ☐ Transmission Service Request Submitted

External to Resource Development: at least two of the following External to Resource Development criteria must be met.

- ☐ Power Plant Permit Application Complete or in Process
- ☐ Power Purchase Agreement Secured or in Negotiation
- ☐ Financing Secured, or Being Secured, for Portion of Project Construction

Phase IV Project

Resource Development: at least two of the following Resource Development criteria must be met.

- ☐ Power Plant Equipment on Order
- ☐ Power Plant Construction Underway
- ☐ Production and Injection Drilling Underway

Transmission Development: for a project to be considered a Phase IV development project the Large Generator Interconnection Agreement must be signed.

If the transmission of power from the project to the end user requires point-to-point service through one or more utility networks then all of the below criteria must be met for the project to be considered a Phase IV development project.

- ☐ Large Generator Interconnection Agreement Signed
- ☐ Transmissions System Service Request Studies Complete

External to Resource Development: all of the following Resource Development criteria must be met.

- ☐ Power Plant Permit(s) Approved
- ☐ EPC Contract Signed
- ☐ PPA Secured

Project Online and in Operation

Appendix B. NLR Geothermal Power Production Database

Plant Name	Field Name	Company	Nameplate Capacity (MW)	Operational Year	Primary Plant Type	Turbine	Status	Decommission Date	EIA Plant ID
Aidlin Unit 1	CA - The Geysers	Calpine	11.2	1989	Dry Steam	Fuji	Operational	N/A	52158
Aidlin Unit 2	CA - The Geysers	Calpine	11.2	1989	Dry Steam	Fuji	Operational	N/A	52158
Beowawe	NV - Beowawe	Ormat	17	1985	Double Flash	Mitsubishi	Operational	N/A	10287
Beowawe 2	NV - Beowawe	Ormat	3.6	2011	Binary	TAS Energy	Operational	N/A	10287
Big Geyser	CA - The Geysers	Calpine	95	1980	Dry Steam	General Electric	Operational	N/A	286F
BLM East Unit 1	CA - Coso	Navy	30	1988	Double Flash	Fuji	Operational	N/A	10875
BLM East Unit 2	CA - Coso	Navy	30	1988	Double Flash	Fuji	Operational	N/A	10875
BLM West Unit 1	CA - Coso	Navy	30	1988	Double Flash	Fuji	Operational	N/A	10875
Blundell 1	UT - Roosevelt	PacifiCorp	30.7	1984	Single Flash	General Electric	Operational	N/A	299
Blundell 2	UT - Roosevelt	PacifiCorp	14.1	2007	Binary	Ormat	Operational	N/A	299
Brady (Brady Complex)	NV - Brady Hot Spring	Ormat	21.5	2018	Binary	Ormat	Operational	N/A	55991
Calistoga	CA - The Geysers	Calpine	97	1984	Dry Steam	Toshiba	Operational	N/A	50066
CD4 - Mammoth Lakes (ORNI 50)	CA - Mammoth	Ormat	44.4	2022	Binary	Ormat	Operational	N/A	63490

Plant Name	Field Name	Company	Nameplate Capacity (MW)	Operational Year	Primary Plant Type	Turbine	Status	Decommission Date	EIA Plant ID
CE Turbo	CA - Salton Sea	CalEnergy	10.35	2000	Single Flash	GE Rotoflow	Operational	N/A	55984
Chena Unit 1	AK - Chena Hot Springs	Chena Hot Springs	0.7	2006	Binary	Turboden	Operational	N/A	none found
Chena Unit 2	AK - Chena Hot Springs	Chena Hot Springs	0.4	2013	Binary		Operational	N/A	none found
Cobb Creek	CA - The Geysers	Calpine	110.0	1979	Dry Steam	Toshiba	Operational	N/A	286E
Cove Fort	UT - Cove Fort	Ormat	30.8	2013	Binary	Ormat	Operational	N/A	58570
Del Ranch (Hoch)	CA - Salton Sea	CalEnergy	45.5	1989	Double Flash	Fuji	Operational	N/A	10632
Desert Peak II (Brady Complex)	NV - Brady Hot Spring	Ormat	26	2007	Binary	Ormat	Operational	N/A	10018
Dixie Valley	NV - Dixie Valley	Ormat	64.7	1988	Double Flash	Fuji	Operational	N/A	52015
Dixie Valley -binary	NV - Dixie Valley	Ormat	6.2	2012	Binary	TAS Energy	Operational	N/A	52015
Don A. Campbell (Wild Rose)	NV - Deadhorse Wells (Wild Rose)	Ormat	25	2014	Binary	Ormat	Operational	N/A	58533
Don A. Campbell II	NV - Deadhorse Wells (Wild Rose)	Ormat	25	2015	Binary	Ormat	Operational	N/A	60419
Eagle Rock	CA - The Geysers	Calpine	110	1975	Dry Steam	Toshiba	Operational	N/A	286D
Elmore	CA - Salton Sea	CalEnergy	45.5	1989	Double Flash	Fuji	Operational	N/A	10634
Elmore (ST-302)	CA - Salton Sea	CalEnergy	8.41	2019	Back Pressure	GE	Operational	N/A	
Faulkner	NV - Blue Mountain	Ormat	49.5	2009	Binary	Ormat	Operational	N/A	56982
Galena I (Richard Burdette) (Steamboat Complex)	NV - Steamboat	Ormat	30	2006	Binary	Ormat	Operational	N/A	56321
Galena II (Steamboat Complex)	NV - Steamboat	Ormat	13.5	2007	Binary	Ormat	Operational	N/A	56540
Galena III (Steamboat Complex)	NV - Steamboat	Ormat	30	2008	Binary	Ormat	Operational	N/A	56541
Goulds I (Heber Complex)	CA - Heber	Ormat	45.5	2006	Binary	Ormat	Operational	N/A	49748

Plant Name	Field Name	Company	Nameplate Capacity (MW)	Operational Year	Primary Plant Type	Turbine	Status	Decommission Date	EIA Plant ID
Goulds II (Heber Complex)	CA - Heber	Ormat	16	2006	Binary	Ormat	Operational	N/A	54111
Grant	CA - The Geysers	Calpine	120	1985	Dry Steam	Toshiba	Operational	N/A	286K
Heber I (Heber Complex)	CA - Heber	Ormat	105	1985	Double Flash	Ormat	Operational	N/A	54689
Heber II (Heber Complex) Second Imperial	CA - Heber	Ormat	48	1993	Binary	Ormat	Operational	N/A	54111
Heber II OEC 1 & 2	CA - Heber	Ormat	42.52	2022	Binary	Ormat	Operational	N/A	54111
Heber South (Heber Complex) Second Imperial	CA - Heber	Ormat	16	2008	Binary	Ormat	Operational	N/A	54111
Hudson Ranch Power I	CA - Hudson Ranch	Cyrq	60	2012	Triple Flash		Operational	N/A	
HXC1	Blackburn	Gradient	0.075	2022	Co-Production	Screw	Operational	N/A	
Jersey Valley	NV - Dixie Valley	Ormat	23.5	2011	Binary	Ormat	Operational	N/A	57376
John L. Featherstone	CA - Salton Sea	Energy Source	55	2012	Triple Flash	Fuji	Operational	N/A	57475
Lake View	CA - The Geysers	Calpine	120	1982	Dry Steam	Toshiba	Operational	N/A	286I
Leathers	CA - Salton Sea	CalEnergy	45.5	1990	Double Flash	Fuji	Operational	N/A	10631
Lightning Dock	NM - Lightning Dock	Zanskar	13.65	2018	Binary	Kaishan	Operational	N/A	58629
Mammoth GI Repowering (Mammoth Complex)	CA - Mammoth	Ormat	10	2013	Binary	Ormat	Operational	N/A	10480
Mammoth GII (Mammoth Complex)	CA - Mammoth	Ormat	15	1990	Binary	Ormat	Operational	N/A	10481
Mammoth GIII Repowering (Mammoth Complex)	CA - Mammoth	Ormat	15	1990	Binary	Ormat	Operational	N/A	10479
McCabe	CA - The Geysers	Calpine	110	1971	Dry Steam	Toshiba	Operational	N/A	286A
McGinness Hills 1	NV - McGinness Hills	Ormat	52	2012	Binary	Ormat	Operational	N/A	57446

Plant Name	Field Name	Company	Nameplate Capacity (MW)	Operational Year	Primary Plant Type	Turbine	Status	Decommission Date	EIA Plant ID
McGinness Hills 2	NV - McGinness Hills	Ormat	48	2015	Binary	Ormat	Operational	N/A	57446
McGinness Hills 3	NV - McGinness Hills	Ormat	74	2018	Binary	Ormat	Operational	N/A	61912
McGinness Hills 3A (ORNI 41) MGH3	NV - McGinness Hills	Ormat	24.8	2021	Binary	Ormat	Operational	N/A	61912
Navy I Unit 1	CA - Coso	Navy	30	1987	Double Flash	Fuji	Operational	N/A	10873
Navy I Unit 2	CA - Coso	Navy	30	1987	Double Flash	Fuji	Operational	N/A	10873
Navy I Unit 3	CA - Coso	Navy	30	1987	Double Flash	Fuji	Operational	N/A	10873
Navy II Unit 1	CA - Coso	Navy	30	1989	Double Flash	Fuji	Operational	N/A	10874
Navy II Unit 2	CA - Coso	Navy	30	1989	Double Flash	Fuji	Operational	N/A	10874
Navy II Unit 3	CA - Coso	Navy	30	1989	Double Flash	Fuji	Operational	N/A	10874
NCPA I No. 2	CA - The Geysers	Northern California Power Agency	110	1983	Dry Steam	Fuji	Operational	N/A	7368
NCPA II	CA - The Geysers	Northern California Power Agency	110	1985	Dry Steam	Toshiba	Operational	N/A	7369
Neal Hot Springs	OR - Neal Hot Springs	Ormat	33	2012	Binary	U.S. Geothermal	Operational	N/A	58022
North Brawley	CA - North Brawley	Ormat	80	2010	Binary	Ormat	Operational	N/A	56832
North Valley (ORNI 36)	NV	Ormat	31.45	2023	Binary	Ormat	Operational	N/A	63491
OIT	OR - Klamath Falls	OIT	0.28	2009	Binary	Pratt & Whitney	Operational	N/A	
OIT	OR - Klamath Falls	OIT	1.75	2014	Binary	Pratt & Whitney	Operational	N/A	
Ormesa I (Ormesa Complex)	CA - East Mesa	Ormat	26.4	1986	Binary	Ormat	Operational	N/A	50766
Ormesa II Upgrade (Ormesa Complex)	CA - East Mesa	Ormat	24	2007	Binary	Ormat	Operational	N/A	54724
Ormesa III (Ormesa Complex)	CA - East Mesa	Ormat	24	2020	Binary	Ormat	Operational	N/A	10763

Plant Name	Field Name	Company	Nameplate Capacity (MW)	Operational Year	Primary Plant Type	Turbine	Status	Decommission Date	EIA Plant ID
Paisley Geothermal	OR - Surprise Valley	Surprise Valley Electric Corp.	3.1	2014	Binary	TAS Energy	Operational	N/A	
Patua Phase 1	NV - Hazen (Black Butte)	Cyrq	36.9	2012	Binary	TAS Energy	Operational	N/A	58319
Puna	HI - Puna	Ormat	35	1993	Binary	Ormat	Operational	N/A	52028
Puna Expansion	HI - Puna	Ormat	16	2012	Binary	Ormat	Operational	N/A	52028
Quicksilver	CA - The Geysers	Calpine	120	1985	Dry Steam	Toshiba	Operational	N/A	286H
Raft River	ID - Raft River	Ormat	18	2008	Binary	U.S. Geothermal	Operational	N/A	56317
Ridgeline	CA - The Geysers	Calpine	110	1982	Dry Steam	Toshiba	Operational	N/A	286B
San Emidio Repower	NV - San Emidio (Empire)	Ormat	11.75	2012	Binary	U.S. Geothermal	Operational	N/A	57456
Salt Wells	NV - Salt Wells (Eight Mile Flat)	Ormat	27.6	2009	Binary	Atlas Copco/Mafi Trench	Operational	N/A	57213
Salton Sea I	CA - Salton Sea	CalEnergy	10.25	1982	Single Flash	Fuji	Operational	N/A	10878
Salton Sea II	CA - Salton Sea	CalEnergy	19.7	1990	Double Flash	Mitsubishi	Operational	N/A	10879
Salton Sea III	CA - Salton Sea	CalEnergy	54	1989	Double Flash	Mitsubishi	Operational	N/A	10759
Salton Sea IV	CA - Salton Sea	CalEnergy	55	1996	Double Flash	GE	Operational	N/A	54996
Salton Sea V	CA - Salton Sea	CalEnergy	58.32	2000	Double Flash	Fuji	Operational	N/A	55983
Socrates	CA - The Geysers	Calpine	120	1983	Dry Steam	Toshiba	Operational	N/A	286J
Soda Lake 3	NV - Soda Lake	Cyrq	26.5	2019	Binary	Ormat	Operational	N/A	
Sonoma	CA - The Geysers	Calpine	78	1983	Dry Steam	Mitsubishi	Operational	N/A	510
Star Peak Geothermal Plant	NV	Open Mountain Energy	21.9	2022	Binary		Operational	N/A	65773
Steamboat 2 (Steamboat Complex)	NV - Steamboat	Ormat	19.4	2008	Binary	Ormat	Operational	N/A	54665
Steamboat 3 (Steamboat Complex)	NV - Steamboat	Ormat	18.2	2008	Binary	Ormat	Operational	N/A	54666
Steamboat Hills (Repower)	NV - Steamboat	Ormat	31.57	2020	Binary	Ormat	Operational	N/A	50654

Plant Name	Field Name	Company	Nameplate Capacity (MW)	Operational Year	Primary Plant Type	Turbine	Status	Decommission Date	EIA Plant ID
Stillwater	NV - Stillwater	Ormat	33.1	2009	Binary	Atlas Copco/Mafi Trench	Operational	N/A	50765
Sulphur Spring	CA - The Geysers	Calpine	117.5	1980	Dry Steam	Toshiba	Operational	N/A	286G
Thermo 1	UT - Thermo Hot Spring	Cyrq	12.34	2013	Binary	Turboden	Operational	N/A	57353
Tungsten Mountain	NV - Tungsten Mountain	Ormat	37	2017	Binary	Ormat	Operational	N/A	60785
Tungsten Mountain 2	NV - Tungsten Mountain	Ormat	25.5	2022	Binary	Ormat	Operational	N/A	60785
Tuscarora	NV - Hot Sulphur Springs	Ormat	32	2012	Binary	Ormat	Operational	N/A	57451
Vulcan	CA - Salton Sea	CalEnergy	39.72	1986	Double Flash	Mitsubishi	Operational	N/A	50210
West Ford Flat	CA - The Geysers	Calpine	28.8	1988	Dry Steam	Mitsubishi	Operational	N/A	10199
Wabuska 3	NV - Wabuska	Open Mountain Energy	4.4	2018	Binary	Kaishan	Operational	N/A	

Appendix C. IGSHPA Member Survey

If you could choose, which words would you use to describe the following terms?

1. **Any heat pump system that employs a heat pump unit that is connected to a closed-loop, open-loop, or standing column well system.**
   a. Geothermal heat pump (GHP)
   b. Ground-source heat pump (GSHP)
   c. Ground-coupled heat pump
   d. Earth-coupled heat pump
   e. Water-source heat pump
   f. GeoExchange

2. **A continuous, sealed, underground, or submerged heat exchanger through which a heat-transfer fluid passes to and returns from a heat pump.**
   a. Ground loop heat pump (GLHP)
   b. Closed-loop system
   c. Closed-source system
   d. Ground heat exchanger (GHEX)

3. **A heat pump system designed to use groundwater. The loop is open at the bottom in an aquifer and water is pumped to the ground surface and circulated through geothermal heat pump.**
   a. Ground water heat pump (GWHP)
   b. Open-loop system
   c. Open-source system

4. **A subsystem of the ground source heat exchanger resulting from the drilling of the vertical borehole, placement of the loop piping to the bottom of the vertical borehole with the grout tremie, and grouting of the vertical borehole from the bottom of the vertical borehole to the earth's surface at the drill site.**
   a. Loop well
   b. Vertical ground heat exchanger
   c. Vertical borehole heat exchanger

5. **The use of geothermal energy to heat/cool buildings through a distribution network**
   a. Geothermal district energy
   b. Geothermal district heating
   c. Community-scale geothermal
   d. Network geothermal
   e. Thermal microgrid
   f. Thermal energy network (TENs)

6. **Does "ground-source heat" include heat energy into and out of the earth AND bodies of surface water?**
   a. Both
   b. Only from the Earth, not surface water.

Appendix D. State Incentive Policies

Note: The information in this appendix was originally compiled between September 2023 and April 2025. Incentives may have changed since then.

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
Alabama	No				
Alaska	Yes	Electric, heat pumps, direct-use	Financial incentive (grant)	These are primarily focused at the community or infrastructure level.	3 AAC 107.600 et seq.
Arizona	No				
Arkansas	No				
California	Yes	Electric, other (lithium extraction from brines)	Financial incentive (grant and loan program)	An applicant is defined as: (1) a local jurisdiction as defined in public resources code section 3807 that has geothermal resources or is impacted by geothermal development; or (2) a private entity as defined in public resources code section 3809.	California PRC Sections 3822 - 3823
		Electric	Financial incentive	Commercial, industrial, government, nonprofit, residential, agricultural	CPUC 399.20
		Electric	Sales tax incentive	Commercial, industrial, agricultural	Cal Rev & Tax Code 6377.1
		Electric	Financial incentive	Industrial	CPUC 26011.8
		Heat pumps	Financial incentive	Residential	AB 1284
Colorado	Yes	Heat pumps	Financial incentive (loan program)	Commercial, industrial, agricultural, non-profit organizations, multifamily (5 units or more)	CRS 32-20-101 et seq.
		Electric, heat pumps	Financial incentive	Commercial, industrial, government, nonprofit, residential, agricultural	CRS 39-26-724
		Electric	Financial incentive	Commercial, industrial, agricultural	CRS 39-4-101 et seq.
		Electric, heat pumps (includes TENs)	Financial (grant)	Commercial, residential, industrial, multifamily, and agricultural property owners.	HB21-1253; SB21-230; HB22-1381

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
Connecticut	Yes	Electric, direct-use	Financial incentive (tax, grant, rebate, and loan program)	Residential, commercial, industrial, schools, agricultural use	Conn. Gen. Stat. § 12-81 (57 et seq., 80)
		Heat pumps, direct-use	Financial incentive	Commercial, residential, installers/contractors	Conn. Gen. Stat. 12-412(117)
		Heat pumps, direct-use	Financial incentive	Commercial, industrial	Conn. Gen. Stat. 12-412(117)(B)
		Heat pumps, direct-use	Financial incentive (tax, grant, rebate, and loan program)	Residential, low-income residential, multifamily	CC-EELP
Delaware	Yes	Electric	Financial (grant program)	Commercial, industrial, local government, nonprofit, residential, schools, agricultural, institutional	7 DE Admin Code 2103
District of Columbia	Yes	Heat pumps	Financial (grant)	Commercial, industrial, investor-owned utility, municipal utilities, residential, cooperative utilities, institutional	DC Code § 8-1773.01 Â§ 8-1774.01 et seq.
		Direct-use	Financial incentive	Commercial, industrial, government, nonprofit, residential	DC Code 8-1778.01 et seq.
Florida	Yes	Heat pumps	Financial (property tax)	Commercial, industrial, residential, agricultural	Florida Statutes § 193.624
		Heat pumps	Financial incentive	Commercial, residential	Florida Statutes Title XI Chapter 163.08 et seq.
Georgia	No				
Hawai'i	Yes	Heat pumps	Financial incentive	Commercial, construction, industrial, residential, installers/contractors	HRS §46-19.6
Idaho	Yes	Electric, heat pumps	Financial (personal tax deduction)	Residential, low income residential	Idaho Code § 63-3022C
		Electric	Financial (bond)	Commercial, industrial, investor-owned utility, government, municipal utilities, cooperative utilities	Idaho Code § 67-8901 et seq.
		Electric	Financial (property tax)	Commercial	Idaho Code § 63-3502B
Illinois	Yes	Heat pumps	Financial (grant program)	Local government, nonprofit, schools, state government, institutional	§ 220 ILCS 5/16-111.1
		Electric, heat pumps	Financial (bond)	Commercial, industrial, nonprofit, schools, institutional	20 ILCS 3501
Indiana	Yes	Electric, heat pumps, direct-use	Financial (property tax)	Commercial, industrial, residential, agricultural, multifamily residential	Ind. Code § 6-1.1-12-26 et seq.

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
Iowa	Yes	Heat pumps	Financial (property tax)	Commercial, industrial, residential, agricultural	Iowa Code § 441.21(8); Iowa Code § 427.1
		Heat pumps	Financial (tax credit)	Residential	701 IAC 42.47
Kansas	Yes	Electric	Financial (property tax)	Commercial, industrial, residential	S.B. 91
Kentucky	Yes	Heat pumps	Financial (loan)	State	KRS 56.770-784
Louisiana	No				
Maine	Yes	Heat pumps	Financial (rebate)	Residential	EMRHESP
		Heat pumps, direct-use	Financial (loan)	Residential	35-A MRSA 10151 et seq.
Maryland	Yes	Heat pumps, direct-use	Financial (property tax)	Commercial, industrial, residential, agricultural	Md Code: Property Tax § 9-203
		Heat pumps	Financial (rebate)	Residential	MD STATE-GOVT §9 20B-01 et seq.
		Heat pumps	Financial (sales tax)	Commercial, industrial, residential, agricultural	Md Code: General Tax §11-230
		Heat pumps	Financial (property tax)	Commercial, industrial, residential	MD Code: Property Tax 9-242
		Heat pumps	Financial (grant)	Commercial, industrial, local government, nonprofit, federal government	MD STATE-GOVT §9-20B-01 et seq.
Massachusetts	Yes	Heat pumps	Financial (sales tax)	Residential	M.G.L. 64H.6(dd)
		Heat pumps	Financial incentive	Commercial, industrial, agricultural, multifamily residential	MGL ch. 23M
		Heat pumps	Financial (rebate)	Commercial, construction, industrial, local government, schools, state government, installers/contractors, institutional	Mass Save
		Heat pumps	Financial (loan)	Residential	Mass Save
Michigan	No				
Minnesota	Yes	Heat pumps	Financial (loan)	Residential	MHFA
		Electric, heat pumps, direct-use	Financial incentive	Commercial, industrial, agricultural	MN Stat. Sec. 216C.436
		Electric, heat pumps, direct-use	Financial incentive	Commercial, industrial, nonprofit, multifamily residential	MN Stat. Sec. 216C.435

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
Mississippi	No				
Missouri	No				
Montana	Yes	Electric, heat pumps, direct-use	Financial (personal tax incentive)	Commercial, industrial, residential, agricultural, multifamily residential	MCA § 15-6-224; MCA § 15-32-102
		Electric	Financial (corporate tax incentive)	Commercial, industrial	MCA § 15-24-1401 et seq
		Heat pumps, direct-use	Financial (loan)	Commercial, nonprofit, local government, residential	MCA 75-25-101 et seq.
		Electric	Financial (tax credit)	Commercial, industrial	MCA 15-32-401 et seq.
		Electric	Financial incentive	Commercial, industrial, nonprofit, agricultural, multifamily residential	MCA 90-4-13
		Electric	Financial (tax abatement)	Commercial, industrial	MCA 15-24-3111; MCA 15-6-157; ARM 17.80.201 and 17.80.202
		Electric	Financial (corporate tax incentive)	Commercial, industrial	MCA § 15-6-225
Nebraska	Yes	Electric	Financial (sales tax)	Industrial, investor-owned utility, municipal utilities, cooperative utilities, installers/contractors	N.R.S. 77-5725
		Electric, heat pumps	Financial (loan)	Commercial, construction, government, nonprofit, residential, agricultural, institutional	NDEE Dollar and Energy Savings Loans
Nevada	Yes	Heat pumps	Financial	Commercial, industrial, investor-owned utility, local government, nonprofit, municipal utilities, residential, cooperative utilities, schools, state government, federal government, tribal government, agricultural, institutional	NAC 704.8901 et seq.
		Electric	Financial (property tax)	Commercial, industrial, investor-owned utility, municipal utilities, cooperative utilities	NRS 701A.300, et seq.; NAC 701A.500
		Electric, heat pumps, direct-use	Financial (sales tax)	Commercial, industrial, investor-owned utility, municipal utilities, cooperative utilities, agricultural	NRS 701A.300, et seq., NAC 701A, et seq.
		Electric, heat pumps, direct-use	Financial (property tax)	Commercial, industrial, agricultural	NRS § 701A.200

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
New Hampshire	Yes	Heat pumps	Financial	Commercial, industrial, agricultural, multifamily residence	NH Stat. 53-F
		Heat pumps	Financial (grant)	Commercial, industrial, government, nonprofit, multifamily	NH Stat. 362-F:10; NH PUC Rule 2500
		Electric, heat pumps	Financial (loan)	Commercial, local government, nonprofit	NH CEF
New Jersey	Yes	Electric, heat pumps, direct-use	Financial (property tax)	Commercial, industrial, residential	N.J. Stat. § 54:4-3.113a et seq.
New Mexico	Yes	Electric	Financial (tax credit)	Commercial, industrial	
New York	Yes	Heat pumps	Financial (property tax)	Commercial, residential, multifamily residential	N.Y. TAX. LAW § 19 : NY Code - Sec. 19
		Electric, heat pumps	Financial	Commercial, industrial, government, nonprofit, multifamily, residential	Case No 13-M-0412
		Heat pumps	Financial incentive	Commercial, industrial, residential	NYCL Gen Mun 119-ee et seq.; NYCL Town 198; NYCL Town 209
North Carolina	No				
North Dakota	Yes	Electric, heat pumps, direct-use	Financial (property tax)	Commercial, industrial, residential, agricultural	ND Century Code 57-02-08(27)
		Electric	Financial (sales tax)	Commercial, industrial	ND Century Code § 57-39.2-04.2 --40.2-04.2
Ohio	Yes	Electric	Financial (property tax)	Commercial, investor-owned utility, municipal utilities, cooperative utilities	ORC 5727.75; OAC 122:23-1 et seq.
		Electric	Financial incentive	Commercial, industrial, government	ORC 37 3706.25 et seq.
		Heat pumps	Financial incentive	Residential	ECO-Link
		Electric	Financial (property tax)	Commercial, investor-owned utility, municipal utilities, cooperative utilities	ORC 5709.53
		Electric	Financial (sales tax)	Commercial, industrial	ORC 5709.20 et seq.; ORC 5709.25; OAC 5703-1-06; ORC 5733.05
		Electric, heat pumps	Financial	Local, residential	ORC 717.25, 1710

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
Oklahoma	No				
Oregon	Yes	Electric, heat pumps, direct-use	Financial (property tax)	Commercial, industrial, residential	ORS § 307.175
		Electric	Financial incentive (grant)	Commercial, industrial, local government, nonprofit, residential, schools, state government, federal government, agricultural	Energy Trust of Oregon
		Electric	Financial (property tax)	Commercial	ORS § 285c; OAR 123-680
Pennsylvania	Yes	Electric, heat pumps, direct-use	Financial (grant/loan)	Commercial, industrial, local government, nonprofit, schools	Special Session H.B. 1
		Heat pumps	Financial (grant/loan)	Commercial, residential	Special Session H.B. 1
		Electric, heat pumps, direct-use	Financial (grant/loan)	Commercial, industrial, local government, nonprofit, schools	Special Session H.B. 1
Rhode Island	Yes	Electric	Financial (property tax)	Residential, multifamily residential, low income residential, appliance manufacturers	R.I. Statutes §44-3-3 (a) (48-49)
		Electric	Financial (grant)	Commercial, industrial, local government, nonprofit, schools, installers/contractors, agricultural, multifamily residential, institutional	RIGL §42-64-13.2
		Heat pumps	Financial (sales tax)	Commercial, residential	RIGL § 44-18-30 (57)
		Heat pumps	Financial (grant)	Agriculture	7 CFR Part 4280 -- Loans and Grants
South Carolina	Yes	Electric, heat pumps	Financial (tax credit)	Commercial, residential	S.C. Code § 12-6-3587
		Electric, heat pumps, direct-use	Financial (tax credit)	Industrial	S.C. Code 12-6-3588
South Dakota	Yes	Electric	Financial (sales tax)	Commercial, industrial, installers/ contractors, agricultural	South Dakota Code § 1-16G-56 et seq.
		Electric, direct-use	Financial (property tax)	Commercial, industrial, residential, agricultural	SDCL § 10-4-42,44 et seq.

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
Tennessee	Yes	Electric	Financial (property tax)	Commercial, industrial, investor-owned utility, municipal utilities, residential, cooperative utilities	Tenn. Code § 67-5-601 et seq.
		Electric	Financial incentive	Industrial	Tenn. Code 67-4-2108, 67-6-346, 67-4-2004
		Heat pumps	Financial incentive	Commercial, industrial, residential, agricultural	Tenn. Code 68-205 et seq.
		Heat pumps	Financial (loan)	Schools	TCA § 49-17-104
		Electric	Financial (sales tax)	Commercial, industrial	TCA § 67-6-346
Texas	Yes	Heat pumps	Financial (loan)	Local government, nonprofit, schools, state government	34 Tex. Admin. Code § 19.41 et seq.
Utah	Yes	Electric, heat pumps, direct-use	Financial (personal tax incentive)	Commercial, residential, multifamily residential, low income residential	Utah Code 59-10-1014
		Electric	Financial (sales tax)	Commercial, industrial, investor-owned utility, municipal utilities, cooperative utilities	Utah Code 59-12-102, 104
		Electric, direct-use	Financial (corporate tax credit)	Commercial, residential, multifamily residential, low income residential	Utah Code 59-7-614
		Electric	Financial (corporate tax credit)	Commercial, industrial	Utah Code 59-7-614.7
		Electric	Financial (personal tax incentive)	Commercial, industrial	Utah Code 79-6-501, 504 et seq.
		Electric, heat pumps, direct-use	Financial (property tax)	Commercial, industrial, agricultural, multifamily residential	Utah Code § 11-42a
Vermont	Yes	Electric, heat pumps, direct-use	Financial (loan)	Agricultural	10 V.S.A. § 280cc to § 280dd
		Electric, heat pumps, direct-use	Financial (loan)	Commercial, local government, nonprofit	10 V.S.A. § 280cc to § 280dd
		Electric, heat pumps	Financial (personal tax incentive)	Commercial, industrial, agricultural	32 V.S.A. § 5822 (d)

State	Is There a State Incentive Policy for Geothermal?	Technology Type	Incentive Type	What Sector(s) Does the Policy Apply to?	Cite
Virginia	Yes	Electric, heat pumps	Financial (loan)	Commercial, industrial, local government, nonprofit, schools, state government, agricultural, institutional	EO 36
		Electric, heat pumps, direct-use	Financial (loan)	Local gov	Va. Code Â§ 62.1-197 et seq.
Washington	Yes	Electric	Financial (sales tax)	Commercial, residential	RCW § 82.08.962
		Electric, heat pumps	Financial	Construction, nonprofit, schools, installers/contractors, agricultural, multifamily residential, low income residential, institutional	WSHFC SEP
West Virginia	No				
Wisconsin	Yes	Electric, heat pumps, direct-use	Financial (grant)	Government, schools, commercial	EIGP
Wyoming	No				

Appendix E. State Regulatory Policies

Note: The information in this appendix was originally compiled between September 2023 and April 2025. Policies and regulations may have changed since then.

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Alabama	No			
Alaska	No			
Arizona	Yes	Direct-Use, Electric	Investor-Owned Utilities	ACC Docket No. RE-00000C-05-0030, Decision No. 69127
Arkansas	Yes	Heat Pumps	State Government	AR Code 22-3-1801 et seq.
		Electric	Commercial, Residential, Government, Industrial, Agricultural	AR Code 23-18-603 et seq.
		Electric	Commercial, Residential, Government, Industrial, Agricultural	AR Code 23-18-601 et seq.
		Electric	Investor-Owned Utilities, Residential, Commercial	APSC SER Action Guide; Docket No. 08-144-U
California	Yes	Electric	Commercial, Residential, Government, Industrial, Agricultural	
		Heat Pumps	State Government	EO B-18-12, CA Code 14710 et seq.
		Electric	Commercial, Residential, Government, Industrial, Agricultural	CPUC Code 2830
		Electric	Commercial, Industrial, Residential	CPUC Decision 12-09-018
		Electric	Investor-Owned Utilities, Municipal Utilities	CPUC Code 399.11 et seq.
		Electric	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities, Commercial, Industrial, Residential	CPUC Code 25710 et seq.

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Colorado	Yes	Electric	Economy wide	
		Electric	Commercial, Residential, Government, Industrial, Agricultural	4 CCR 723-3, Rules 3664 and 3800
		Heat Pumps	State Government	CRS 24-30-13 et seq., CRS 22-32-124.3
		Electric	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities, Commercial, Industrial, Residential	4 CCR 723-3 Rule 3850 et seq.
		Electric	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities	4 CCR 723-3 Rule 3650 et seq.
		Electric	Investor-Owned Utilities	CRS 40-2-127.5
Connecticut	Yes	Electric	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities	Conn. Gen. Stat. 16-1
		Heat Pumps	State Government	Conn. Gen. Stat. § 16a-38k
		Electric	Commercial, Industrial, Government, Residential	Conn. Gen. Stat. § 16-244z
Delaware	Yes	Electric	Investor-Owned Utility, Local Government, Retail Supplier	26 Del. C. § 351 et seq.
		Heat Pumps	State Government	29 Del. C. § 6939 Executive Order No. 18 (Markell)
		Electric, Heat Pumps	Commercial, Industrial, Investor-Owned Utility, Municipal Utilities, Residential, Cooperative Utilities	26 Del. C. § 363
District of Columbia	Yes	Electric	Investor-Owned Utility, Retail Supplier	D.C. Law 22-257 D.C. Official Code § 34-1431 et seq.
		Heat Pumps	Commercial, Schools, State Government	D.C. Code § 6-1451.01 et seq D.C. Law 24-177
		Electric	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities, Commercial, Industrial, Residential	D.C. Code 8-1774.01 et seq.
		Electric	Commercial, Industrial, Residential	D.C. Code 34-1501 et seq.
		Electric	Commercial, Industrial, Government, Residential	DCMR 15-4000 et seq.
		Electric	Residential, Multifamily Residential, Low Income Residential	D.C. Act 20-186

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Florida	Yes	Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Tribal Government, Agricultural, Institutional	25-6.065, F.A.C FL Stat. § 366.91
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Tribal Government, Agricultural, Institutional	25-6.065, F.A.C.; FL Stat. § 366.91
Georgia	No			
Hawai'i	Yes	Electric	Commercial, Industrial, Nonprofit, Residential, Schools, State Government, Federal Government	HRS § 269-101 et seq.; HI PUC Order No. 19773; Decision & Order No. 24238; Decision & Order No. 24159; HI PUC Docket No. 2010-0015, Decision & Order
		Electric	Investor-Owned Utilities	HRS 269-91 et seq.
		Heat Pumps	Schools, State Government	HRS §196-9 et seq.
Idaho	No			
Illinois	Yes	Electric	Commercial, Industrial, Investor-Owned Utility, Municipal Utilities, Residential, Cooperative Utilities, Schools, Institutional	§ 20 ILCS 687/6-1 et seq.
Illinois	Yes	Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional	§ 220 ILCS 5/16-107.5 83 Ill. Adm. Code, Part 466 83 Ill. Adm. Code, Part 467
		Heat Pumps	State Government	§ 20 ILCS 20/1 et seq. EO 7 (2009) § 20 ILCS 3130/1 et seq.
Indiana	Yes	Heat Pumps	State Government	Executive Order 08-14
		Electric, Heat Pumps, Direct-Use	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities, Retail Supplier	IC 8-1-37 IURC RM #11-05 170 IAC 17.1
Iowa	Yes	Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional	199 IAC 15.10; IUB Order, Docket No. RMU-2009-0008; Iowa Code § 476.6A; H.F. 548; 199 IAC 45

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Kansas	No			
Kentucky	No			
Louisiana	Yes	Electric	Commercial, Residential, Agricultural	La. R.S. 51:3061 et seq.
		Electric	Commercial, Industrial, Residential, Agricultural	La. R.S. 51:3061 et seq.
Maine	Yes	Electric	Commercial, Local Government, Nonprofit, Residential, Schools, Institutional	35-A M.R.S. § 3210 35-A M.R.S. § 10101 et seq. CMR 95-648 Chapter 103
		Electric	Commercial, Industrial, Nonprofit, Residential, Schools, Agricultural, Multifamily Residential, Institutional	CMR 65-407-313 35-A MRSA §3209-A 35-A MRSA §3209-B
		Electric	Investor-Owned Utility, Retail Supplier	35-A M.R.S. § 3210 CMR 65-407-311 35-A M.R.S. § 3210-C Public Law 413 H.P 810 / L.D. 1147 LD 1494
		Heat Pumps	State Government	5 M.R.S. § 1764-A Maine Executive Order 13 FY 19/20
		Electric	Commercial, Investor-Owned Utility, Residential, Multifamily Residential	35-A M.R.S. §3212-A CMR 65-407-326 Order Selecting Green Power Supplier
		Electric	Transmission and Distribution Utilities	CMR 65-407-324 Resolve, Chapter 183, 123rd Legislature 2013-00531: Order Adopting Standard Form Interconnection Agreement 2013-00263: Order Adopting Rule
Maryland	Yes	Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional	COMAR 20.50.09 Small Generator Interconnection Standards

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Maryland	Yes	Electric, Direct-Use, Heat Pumps	Investor-Owned Utility, Local Government, Retail Supplier	Md. Public Utilities Code § 7-701 et seq. COMAR 20.61.01 et seq. H.B. 226 H.B. 1106 Clean Energy Jobs- RPS Revisions
		Heat Pumps	Construction, Schools, State Government	Executive Order 01.01.2023.07 High-Performance Green Building Program SEC 301
Massachusetts	Yes	Electric	Investor-Owned Utilities	M.G.L. ch. 164, § 138-140 220 CMR 18.00 220 CMR 8.00 et seq.
		Electric	Investor-Owned Utility, Retail Supplier	M.G.L. ch. 25A, § 11F 225 CMR 14.00 225 CMR 15.00
		Electric, Heat Pumps	Commercial, Industrial, Investor-Owned Utility, Local Government, Nonprofit, Municipal Utilities, Residential, Cooperative Utilities, Schools, State Government, Agricultural, Institutional	M.G.L. ch. 25, § 20 M.G.L. ch. 23J, § 9
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Multifamily Residential	M.G.L. ch. 164, 138-140
		Heat Pumps, Direct-Use	Commercial, Industrial, Investor-Owned Utility, Nonprofit, Municipal Utilities, Residential, Cooperative Utilities, Schools, Agricultural, Institutional	M.G.L. ch. 25 § 19 M.G.L. ch. 25A § 11G
		Heat Pumps	Local Government, Schools, State Government, Institutional	Executive Order 594 (2021) Executive Order 569 (2016) Executive Order 594 Section 3
		Electric	State Government	Clean Energy and Climate Plan for 2030
		Heat Pumps	Investor-Owned Utility, Retail Supplier	M.G.L. ch. 25A § 11F 1/2 225 CMR 16.00
		Electric	Investor-Owned Utility, Retail Supplier	225 CMR 21.00
		Electric	Investor-Owned Utility, Retail Supplier	310 CMR 7.75

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Michigan	Yes	Heat Pumps	State Government	MCL § 460.1131 et seq. Executive Directive 2007-22 Executive Directive 2020-10
		Electric, Heat Pumps	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities, Retail Supplier	MCL § 460.1001 et seq.
Minnesota	Yes	Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities, Retail Supplier	Minn. Stat. 216B.1691
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Installers/Contractors, Tribal Government, Agricultural, Multifamily Residential, Institutional	Minn. Stat. § 216B.1611 Minnesota Distributed Energy Resource Interconnection Process and Agreement Minn. R. 7835.4750
		Heat Pumps	State Government	Minn. Stat. 16B.32 et seq. Minn. Stat. 216B.241(9) EO 11-12 EO 11-13 EO 19-27 HF 1752
		Electric	Commercial, Industrial, Investor-Owned Utility, Local Government, Nonprofit, Municipal Utilities, Residential, Cooperative Utilities, Schools, State Government, Federal Government, Tribal Government, Agricultural, Institutional	Minn. Stat. § 116C.779
Mississippi	Yes	Electric	Commercial, Industrial, Investor-Owned Utility, Municipal Utilities, Residential, Cooperative Utilities, Agricultural, Multifamily Residential, Low Income Residential	Mississippi Administrative Code Title 39 Part 4 PSC Subpart II
		Electric	Commercial, Industrial, Investor-Owned Utility, Municipal Utilities, Residential, Cooperative Utilities, Federal Government, Low Income Residential	Mississippi Administrative Code Title 39 Part 4 PSC Subpart I
Missouri	Yes	Electric, Heat Pumps, Direct-Use	State Government	8.800 R.S. Mo., et seq. Executive Order No. 09-18 10 CSR 140-7.010
Montana	Yes	Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	MCA 69-8-210

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Montana	Yes	Electric	Investor-Owned Utility, Retail Supplier	MCA 69-3-2001 et seq. MONT. ADMIN. R. 38.5.8301 H.B. 20
		Electric	Commercial, Industrial, Investor-Owned Utility, Municipal Utilities, Residential, Cooperative Utilities, Institutional	MCA 69-8-402 MONT. ADMIN. R. 42.29.101 et seq. SB 11 (2015)
Nebraska	Yes	Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional	R.R.S. 70-2001, et seq.
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Installers/Contractors, Agricultural, Multifamily Residential, Institutional	R.R.S. 70-2001, et seq.
Nevada	Yes	Heat Pumps	State Government	NRS 333.4611 NRS 341.144 NAC 341.301 et seq.
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government	NRS 704.744 NV Energy Rule 15
		Electric, Heat Pumps, Direct-Use	Investor-Owned Utility, Retail Supplier	NAC 704.8831 et seq. LCB File R167-05 NRS 704.7801 et seq.
		Electric	Commercial, Industrial, Government, Residential	NRS 704.766 et seq. NAC 704.881 et seq. Public Utilities Commission Final Order
New Hampshire	Yes	Heat Pumps	Investor-Owned Utility, Cooperative Utilities, Retail Supplier	RSA 362-F NH Admin Rules PUC 2500
		Electric	Commercial, Industrial, Government, Residential	RSA 362-A: 1-a & RSA 362-A: 9 NH Admin Rules PUC 900
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional	RSA 362-A: 1-a & RSA 362-A: 9 NH Admin Rules PUC 900

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
New Jersey	Yes	Electric	Investor-Owned Utilities, Retail Supplier	NJ Stat. 48:3-49 et seq. NJAC 14:8-1 & 14:8-2 SB 1925 AB 3455 AB 3723
		Heat Pumps	Schools	EO 24 NJ EFCFA NJAC 6A:26 - Educational Facilities
		Heat Pumps	State Government	NJ Stat. 52:32-5.4 et seq. NJ Stat. 52:34-6.4 EO 24
		Electric	Commercial, Industrial, Residential, Utilities	NJ Stat. 48:3-87 NJAC 14:8-4.1 et seq. SB 1925 SB 2420
		Electric	Commercial, Industrial, Government, Utilities, Residential	NJ Stat. 48:3-60 et seq.
		Electric	Commercial, Industrial, Government, Utilities, Residential	NJ Stat. 48:3-87 NJAC 14:8-5.1 et seq.
New Mexico	Yes	Electric	Commercial, Industrial, Residential, Government, Nonprofit, Agricultural	NMAC 17.9.570
		Electric	Commercial, Industrial, Nonprofit, Government, Schools	NMAC 17.9.568 NMAC 17.9.569 Final Order Docket No. 21-00266-UT
		Electric	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities	NMAC 17.9.572
		Electric	Investor-Owned Utilities, Cooperative Utilities	NM Stat. 62-16-1 et seq. NM Stat. 62-15-34 et seq. NMAC 17.9.572 Revised Final Order, Case No. 13-00152

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
New York	Yes	Electric	Commercial, Industrial, Investor-Owned Utility, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural	PUC Order Authorizing the Clean Energy Fund Framework
		Electric	Commercial, Industrial, Investor-Owned Utility, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural	NY PSC Opinion 96-12 NY PSC Case 94-E-0952 NY PSC Case 05-M-0090 NY PSC Case 10-M-0457
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Institutional	NY PSC Order Case 94-E-0952 NY PSC Order Case 02-E-1282 NY PSC Order Case 08-E-1018 NY PSC Order Cases 12-E0393 through 12-E-0398 NY Standard Interconnection Requirements NY PSC Order Case 15-E-0557
North Carolina	Yes	Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities,	N.C. Gen. Stat. § 62-133.8 04 NCAC 11 R08-67
North Dakota	Yes	Electric	Investor-Owned Utilities, Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Residential	ND Administrative Code 69-09-07-09
		Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	ND Century Code § 49-02-24 et seq. ND PSC Order PU-07-318 ND Admin. Code 69-09-08
Ohio	Yes	Electric	Investor-Owned Utility, Retail Supplier	ORC 4928.64 et seq. OAC 4901:1-40 et seq. HB 6 - 2019
		Electric	Commercial, Industrial, Residential, Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities	ORC 4928.61 et seq.
		Electric	Investor-Owned Utilities	ORC 4928.11 OAC 4901:1-22

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Ohio	Yes	Heat Pumps	Schools	OSFCR 07-124 ORC 3318.112 ORC 3318:1-9-01
Oklahoma	Yes	Heat Pumps	Government	61 OS 213
		Electric	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities	17 OS 801.1 et seq.
		Electric	Commercial, Industrial, Government, Residential, Schools	OAC 165:40-9-1 et seq. EO 2014-07 17 OS 156
Oregon	Yes	Electric	Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Residential, Institutional	OR Revised Statutes 757.300 OR Admin R 860-022-0075 OR Admin R 860-039
		Electric	Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Institutional	Model Ordinance for Renewable Energy Projects - 2005
		Electric	Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Institutional	ORS § 757.300 OR Admin R 860-039 OR Admin R 860-082
		Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	ORS §757.603 HB 2941
		Heat Pumps	Commercial, Industrial, Utility, Government, Schools, Agricultural, Residential, Industrial	ORS 757.612 et seq. SB 1149
		Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities, Retail Suppliers	ORS 469A
		Electric, Heat Pumps, Direct-Use	State Government	ORS 279C.527-528
Pennsylvania	Yes	Electric, Heat Pumps	Investor-Owned Utility, Retail Supplier	73 P.S. § 1648.1 et seq.
		Heat Pumps, Direct-Use	Investor-Owned Utility	66 P.S. 2806.1
		Heat Pumps	Commercial, Industrial, Utility, Residential, Institutional	

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Rhode Island	Yes	Electric	Investor-Owned Utility, Retail Supplier	R.I. Gen. Laws § 39-26-1 et seq.
		Electric	Government, Nonprofit, Residential, Schools, Institutional	R.I. Gen. Laws § 39-26.4
		Electric	Commercial, Industrial, Investor-Owned Utility, Municipal Utilities, Residential, Cooperative Utilities, Institutional	R.I. Gen. Laws 39-2-1.2
		Heat Pumps	State Government	R.I. Gen. Laws § 37-24-1 et seq.
		Electric	Investor-Owned Utilities	R.I. Gen. Laws § 39-26.3
South Carolina	Yes	Electric	Commercial, Investor-Owned Utility, Nonprofit, Municipal Utilities, Residential, Cooperative Utilities, Schools, Institutional	Order No. 2021-390 Order No. 2021-391
		Electric, Heat Pumps, Direct-Use	Utilities	SC Code 58-39-110 et seq.
South Dakota	Yes	Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	SDCL § 49-34A-101 et seq.
		Heat Pumps	State Government	SDCL § 5-14-32 et seq.
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Tribal Government, Agricultural, Institutional	S.D. Admin Code § 20:10:36
Tennessee	No			
Texas	Yes	Electric	Investor-Owned Utility, Retail Supplier	Public Utility Regulatory Act, TEX. UTIL CODE ANN. § 39.904 (PURA)
		Heat Pumps	Investor-Owned Utility	Texas Utilities Code § 39.905
		Electric	Investor-Owned Utility, Commercial, Industrial, Residential	16 TAC § 25.211 et seq.
Utah	Yes	Electric	Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Residential, Institutional	Utah Code § 54-15-101 et seq.
		Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	Utah Code 54-17-601 et seq.; Utah Code 10-19-101 et seq.
		Electric	Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Institutional, Utilities	Utah Code § 54-15-101 et seq.

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Vermont	Yes	Electric	Commercial, Government, Nonprofit, Residential, Schools, Institutional, Utilities	30 V.S.A. § 8010
		Electric, Heat Pumps	Investor-Owned Utilities, Municipal Utilities, Cooperative Utilities, Retail Supplier	30 V.S.A. § 8001 et seq.
		Electric, Heat Pumps, Direct-Use	Commercial, Industrial, Nonprofit, Residential, Schools, Agricultural, Institutional	10 V.S.A. § 8015
		Electric	Commercial, Government, Residential, Nonprofit, Schools	30 V.S.A. § 8010
Virginia	Yes	Electric	Commercial, Industrial, Government, Nonprofit, Residential, Agricultural, Institutional, Utilities	Va. Code § 56-594
		Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	Va. Code § 56-577-5A
		Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	Va Code § 56-585.5.
		Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Schools, State Government, Federal Government, Agricultural, Utilities	20 VAC 5-315-40 et seq. Va. Code § 56-578 20 VAC 5-314
Washington	Yes	Electric	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	RCW 19.285; 480-109 WAC
		Electric	Investor-Owned Utility, Cooperative Utilities	RCW 19.29A.090
		Electric	Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Institutional	Chapter 480-108 WAC
		Electric, Heat Pumps	State Government	RCW § 39.35D.010 et seq.
West Virginia	Yes	Electric	Commercial, Industrial, Local Government, Nonprofit, Residential, Agricultural, Utilities	WV Code § 24-2F-1 et seq.
		Electric	Commercial, Industrial, Residential, Agricultural	WV Code § 24-2F-1 et seq.

State	Is There an Existing Regulatory Policy	Technology Type	Applicable Sectors	Citation
Wisconsin	Yes	Electric	Commercial, Industrial, Residential, Investor-Owned utilities, Municipal Utilities	PSC Docket 05-EP-6 PSC Docket 4220-UR-117
		Electric	Commercial, Industrial, Government, Nonprofit, Residential, Institutional	WI Stat. 196.496
		Electric, Heat Pumps	Investor-Owned Utility, Municipal Utilities, Cooperative Utilities	WI Stat. § 196.378
		Heat Pumps	Commercial, Industrial, Government, Nonprofit, Residential, Schools, Agricultural, Institutional	WI Stat. 196.374
		Heat Pumps	State Government	WI Stat. 101.027
		Electric	State Government	WI Stat. 16.75(12)
Wyoming	No			

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