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Ali Javaheri
Analyst, Emerging Technology
ali.javaheri@pitchbook.com

EMERGING SPACE BRIEF

Geothermal Power

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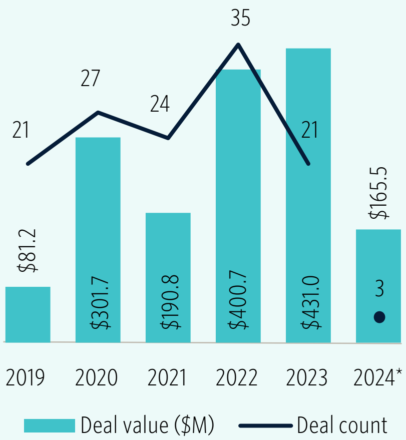
pbinstitutionalresearch@pitchbook.com

Trending companies

Eavor, Sage Geosystems, Verne Global, Eden, Ormat, Fervo Energy

Geothermal power VC deal activity



Source: PitchBook • Geography: Global
*As of February 25, 2024

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Overview

Geothermal energy harnesses the Earth's deep-seated heat for electricity production. This method involves tapping into the Earth's crust to access internal heat, which then generates steam to propel turbines connected to generators. Unlike solar or wind energy, which can be affected by weather conditions, geothermal power provides a steady supply of electricity, making it a dependable and sustainable choice for base-load power generation. Its ability to deliver continuous energy output simplifies its integration into electrical grids by eliminating the need for mechanisms to manage intermittency issues often associated with other renewable sources. It is important to note, however, that this brief's definition of geothermal power excludes ground-source heat pumps, which, although they utilize heat from the Earth, are not included in the same category for electricity generation.

Background

The history of geothermal power is a testament to human ingenuity, tracing back over 10,000 years when Indigenous peoples in North America and ancient civilizations such as the Greeks and Romans harnessed hot springs for cooking, bathing, and heating. This age-old practice evolved significantly in 1827 in Italy, where natural steam was first used industrially. A pivotal moment occurred in 1904 when Italian scientist Piero Ginori Conti generated electricity using geothermal steam, leading to the world's first commercial geothermal power plant in Larderello, Italy, in 1911. The progression of geothermal energy saw a significant leap with the establishment of the first large-scale electricity-generating plant at The Geysers in California in 1960.

Further advancements have expanded geothermal energy's applications and efficiency, raising the possibility of geothermal power's role in the global renewable-energy mix. Despite geothermal energy currently representing a mere 0.5% of the global renewables-based installed capacity for electricity generation, heating, and cooling,[1] it is considered capable of producing up to 8.3% of the world's total electricity, potentially supplying 17% of the global population, with 39 countries, primarily in Africa, South America, and the Pacific, having the potential to generate 100% of their electricity needs through geothermal resources.[2] The Inflation Reduction Act in the US has further bolstered the geothermal energy sector, offering Investment Tax Credits (ITCs) and Production Tax Credits (PTCs) to incentivize geothermal development among other low-carbon technologies. These fiscal measures highlight the ongoing commitment to renewable energy and the potential for geothermal power to play a greater role in achieving a sustainable and low-carbon future.

1: "Global Geothermal Market and Technology Assessment," International Renewable Energy Agency, February 2023.
2: "World Energy Resources: Geothermal," World Energy Council, 2013.

Technologies and subsegments

The core methodologies for converting geothermal energy into electricity are categorized into dry steam, flash steam, and binary cycle plants, with each representing a unique approach to harnessing subterranean heat.

Dry steam plants: The oldest form of geothermal power generation, dry steam plants utilize steam directly from underground resources to drive turbines and generate electricity. This method bypasses the need for an intermediary fluid or process, thus allowing for a straightforward conversion of geothermal steam to electrical energy. Dry steam plants require geothermal resources with temperatures high enough to naturally produce steam, a relatively rare occurrence that limits their applicability to specific geothermal hot spots.

Flash steam plants: Flash steam plants are more common than dry steam plants and can operate at lower temperatures. They work by drawing up hot water under pressure from geothermal reservoirs. As the water is brought to the surface, the decrease in pressure causes it to “flash,” or rapidly vaporize into steam, which then drives a turbine. Any leftover water and condensed steam are injected back into the reservoir, making this process more sustainable. Flash plants typically require water at temperatures of at least 182 degrees Celsius (C) (360 degrees Fahrenheit [F]) and are more efficient than dry steam plants in converting geothermal energy into electricity.

Binary cycle plants: Representing a significant technological advancement in the field, binary cycle plants can operate at even lower temperatures of around 107 degrees C (225 degrees F) and up, expanding the potential for geothermal electricity generation to areas with less intense geothermal activity. In these plants, geothermal fluid heats a secondary fluid with a lower boiling point in a heat exchanger. The secondary fluid vaporizes and drives the turbines. Because the geothermal fluid and secondary fluid are kept separate, and the geothermal water is not exposed to the atmosphere, binary cycle plants minimize environmental impact by virtually eliminating emissions.

Enhanced geothermal systems (EGS) and advanced geothermal systems (AGS): Beyond these traditional methods, EGS and AGS represent innovative approaches to create and exploit geothermal resources. EGS involves fracturing hot dry rock to circulate water through the created pathways, indirectly capturing the Earth’s heat. AGS, or closed-loop systems, circulate a working fluid through sealed underground pipes to absorb heat by conduction, offering a flexible and environmentally friendly solution for geothermal energy extraction.

Applications

Geothermal power's clearest application is in straightforward electricity generation. In 2022, geothermal power plants in the US produced 17 billion kilowatt-hours of electricity, or 0.4% of total US utility-scale electricity generation.[3] Another common application is to directly heat individual buildings or to heat multiple buildings through district heating systems. An emerging innovation in this application is deep direct-use, which uses lower-temperature geothermal resources and thus can deploy at a much larger scale.[4]

The industrial sector leverages geothermal energy for processes including drying agricultural produce, pasteurizing milk, and enhancing mineral extraction activities such as gold mining. Innovative companies are developing technologies to extract lithium from deep geothermal waters, concurrently generating heat and electricity. In agriculture, geothermal energy plays a crucial role in soil sterilization, which improves crop yields by controlling pests and diseases. Additionally, geothermal energy offers a sustainable solution for desalination by employing heat to transform seawater into freshwater, thus tackling water scarcity challenges.

Limitations

Affordability and capital intensiveness: A significant barrier to the development of geothermal power is its high cost and capital-intensive nature. For instance, in 2022, the capital expenditure required for a next-generation geothermal project exceeded $8.7 million per megawatt (MW), which is substantially higher than the $1.8 million/MW expenditure for onshore wind and $1.1 million/MW expenditure for solar plants.[5] These costs escalate further with the increase in temperature and depth required for geothermal projects.[6] Additionally, the financing costs for geothermal projects are higher due to the increased risk, with a weighted average cost of capital at the predrilling stage approximately 15% higher than the cost of capital for wind and solar projects.[7]

Scalability concerns: While recent developments have proven the technical feasibility of next-generation geothermal projects on a small scale, the effectiveness, plausibility, and safety of scaling these projects to a larger size remain uncertain. The industry awaits insights from commercial projects planned for the coming years to address these scalability issues.

Regulatory and social acceptance: The expansion of geothermal energy is also contingent on the establishment of supportive regulatory frameworks and gaining social acceptance. Efforts to shorten project approval timelines, reduce financing barriers, and encourage investment are necessary. Additionally, addressing concerns such as seismic risks associated with geothermal power plants through ongoing studies and probabilistic modeling is crucial for wider acceptance.

3: "Geothermal Explained," US Energy Information Administration, November 22, 2023.
4: "Energy Department Explores Deep Direct-Use," Office of Energy Efficiency and Renewable Energy, February 25, 2015.
5: "Next-Generation Geothermal Technologies Are Heating Up," BloombergNEF, Yiyi Zhou and Meredith Annex, May 10, 2023.
6: Ibid.
7: Ibid.

Geographical and environmental constraints: Geothermal power generation requires proximity to geothermal resources, which are typically located near tectonic plate boundaries or areas with shallow geothermal heat.[8] Furthermore, the sustainability of geothermal sites can be compromised by local heat depletion if extraction rates are not carefully managed.[9] Although geothermal energy is a cleaner alternative to fossil fuels, it is not without environmental impact. The drilling process can release greenhouse gases, albeit at lower levels than fossil fuel technologies.[10] Moreover, the injection of water and fluids under pressure can induce localized seismic events, such as the Pohang earthquake in South Korea in 2017, highlighting the environmental considerations that must be addressed.[11]

Recent deal activity and market outlook

For more on VC activity in clean energy, refer to our Q4 2023 Clean Energy Report.

The recent VC deal activity within the geothermal power sector underscores a vibrant and evolving market, but still one that garners far less VC than other renewables. Fervo Energy, valued at $538.5 million, successfully secured $138.5 million in funding in February 2024, with a valuation step-up of 2.4x. This highlights the potential of its innovative horizontal drilling technique and hydraulic fracturing method, which was demonstrated by a successful commercial pilot in Nevada in July 2023. Similarly, Eavor's innovative closed-loop system attracted $182.0 million for projects in New Mexico and Germany, indicating strong investor confidence in next-generation geothermal technologies.

The Inflation Reduction Act in the US has further bolstered the sector by extending tax credits to encourage the development of low-carbon technologies, including geothermal power. These incentives, comprising ITCs, which could cover up to 30% of investment costs, and PTCs, which offer $25 per megawatt-hour of electricity produced, enhance the financial viability of geothermal projects.

Despite these positive developments, the geothermal power sector faces challenges related to affordability, scalability, and regulatory frameworks. The high capital expenditure of over $8.7 million/MW for next-generation projects, as well as a weighted average cost of capital at the predrilling stage that is roughly 15% higher than that for wind and solar projects, highlights the financial barriers to entry.[12] Scalability concerns remain, with the effectiveness of larger-scale projects yet to be fully proven. Regulatory and social acceptance issues, alongside the need for improved regulatory frameworks to facilitate project approvals and investments, are critical for the sector's growth.

International interest in geothermal energy is widening, with Japan and Taiwan setting ambitious targets to incorporate geothermal power into their energy mix. Partnerships in Latin America indicate a growing recognition of geothermal's potential for energy security and carbon emission reduction.

8: "Hype Cycle for Low-Carbon Energy Technologies, 2023," Gartner, Simon Cushing and Lauren Wheatley, July 25, 2023.
9: Ibid.
10: Ibid.
11: Ibid.
12: "Next-Generation Geothermal Technologies Are Heating Up," BloombergNEF, Yiyi Zhou and Meredith Annex, May 10, 2023.

For a deeper dive into the data and to explore additional insights, visit the PitchBook Platform or request a free trial.

Quantitative perspective*

73 companies	**299** deals	**430** investors	**$4.6B** capital invested
34 deals (TTM) *-2.9% YoY*	**$10.0M** median deal size (TTM) *254.2% YoY*	**$82.0M** median post-money valuation (TTM) *76.3% YoY*	**$1.1B** capital invested (TTM) *158.4% YoY*

*As of February 25, 2024

Top geothermal power companies by total raised*

Company	Total raised ($M)	Last financing size ($M)	Last financing date	Last financing deal type	HQ location	Year founded
Ormat Technologies	$700.7	$342.0	March 16, 2023	Public investment second offering	Reno, US	1965
Fervo Energy	$325.9	$138.5	February 22, 2024	Late-stage VC	Houston, US	2017
Eavor	$288.5	N/A	December 21, 2023	Late-stage VC	Calgary, Canada	2017
Alterra Power	$218.2	$363.0	February 6, 2018	M&A	Vancouver, Canada	N/A
Sinopec Green Energy	$200.0	$200.0	December 10, 2020	Late-stage VC	Baoding, China	2006
Dandelion Energy	$135.7	N/A	N/A	Late-stage VC	Mount Kisco, US	2017
Verne Global	$125.0	N/A	October 27, 2023	M&A	Reykjavík, Iceland	2007
EnergySource	$90.0	N/A	N/A	PE growth/expansion	Carlsbad, US	2006
ThermaSource	$84.0	N/A	February 13, 2015	Out of business	Santa Rosa, US	1980
Quaise	$83.1	$13.1	December 11, 2023	Late-stage VC	Cambridge, US	2018

Source: PitchBook • Geography: Global
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Top geothermal power companies by Exit Predictor opportunity score*

Company	Opportunity score	Success probability	M&A probability	IPO probability	Total raised ($M)	HQ location	Year founded
Quaise	98	92%	82%	10%	$83.1	Cambridge, US	2018
LunaSonde	94	84%	78%	6%	$9.8	Tucson, US	2016
Eden	89	82%	81%	1%	$13.1	Somerville, US	2017
Angara Global	84	75%	70%	5%	$19.6	London, UK	2015
GreenFire Energy	82	73%	68%	5%	$21.2	Walnut Creek, US	2010
Sage Geosystems	82	75%	74%	1%	$59.0	Houston, US	2020
XGS Energy	81	73%	71%	2%	$28.8	Palo Alto, US	2008
Zanskar	77	71%	69%	2%	$15.4	Salt Lake City, US	2019
Dandelion Energy	76	87%	75%	12%	$135.7	Mount Kisco, US	2017
Eavor	75	78%	7%	71%	$288.5	Calgary, Canada	2017

Source: PitchBook • Geography: Global
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Note: Probability data is based on PitchBook VC Exit Predictor methodology.

Top geothermal power companies by active patents*

Company	Active patent documents	Total raised ($M)	HQ location	Year founded
Ormat Technologies	298	$700.7	Reno, US	1965
GroundMetrics	62	$12.9	San Francisco, US	2010
HyperSciences	54	$26.6	Spokane, US	2014
ICE Thermal Harvesting	53	N/A	Houston, US	2021
Eavor	49	$288.5	Calgary, Canada	2017
Seismos	34	$17.1	Austin, US	2013
GreenFire Energy	27	$21.2	Walnut Creek, US	2010
O-Flexx Technologies	27	$9.0	Duisburg, Germany	2006
AltaRock	20	$40.7	Seattle, US	2007
GA Drilling	20	$8.0	Bratislava, Slovakia	2008
Vision IO	17	N/A	Stavanger, Norway	2008

Source: PitchBook • Geography: Global
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Top geothermal power investors*

Investors	Investments	HQ location
US Department of Energy	21	Washington, DC, US
Collaborative Fund	8	New York, US
Breakthrough Energy	6	Kirkland, US
Nabors Industries	6	Hamilton, Bermuda
Building Ventures	5	Boston, US
Helmerich & Payne	5	Tulsa, US
New Enterprise Associates	5	Menlo Park, US

Source: PitchBook • Geography: Global
*As of February 25, 2024

Recommended reading

- "Enhanced Geothermal Systems: 10 Breakthrough Technologies 2024," MIT Technology Review, June Kim, January 8, 2024.
- "Next-Generation Geothermal Technologies Are Heating Up," BloombergNEF, Yiyi Zhou and Meredith Annex, May 10, 2023.
- "Geothermal Power: Technology Brief," International Renewable Energy Agency, September 2017.
- "Geothermal Energy Is Poised for a Big Breakout," Vox, David Roberts, October 21, 2020.
- "Electricity Generation," Office of Energy Efficiency & Renewable Energy, Geothermal Technologies Office, n.d., accessed March 4, 2024.