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Enhanced Geothermal Systems

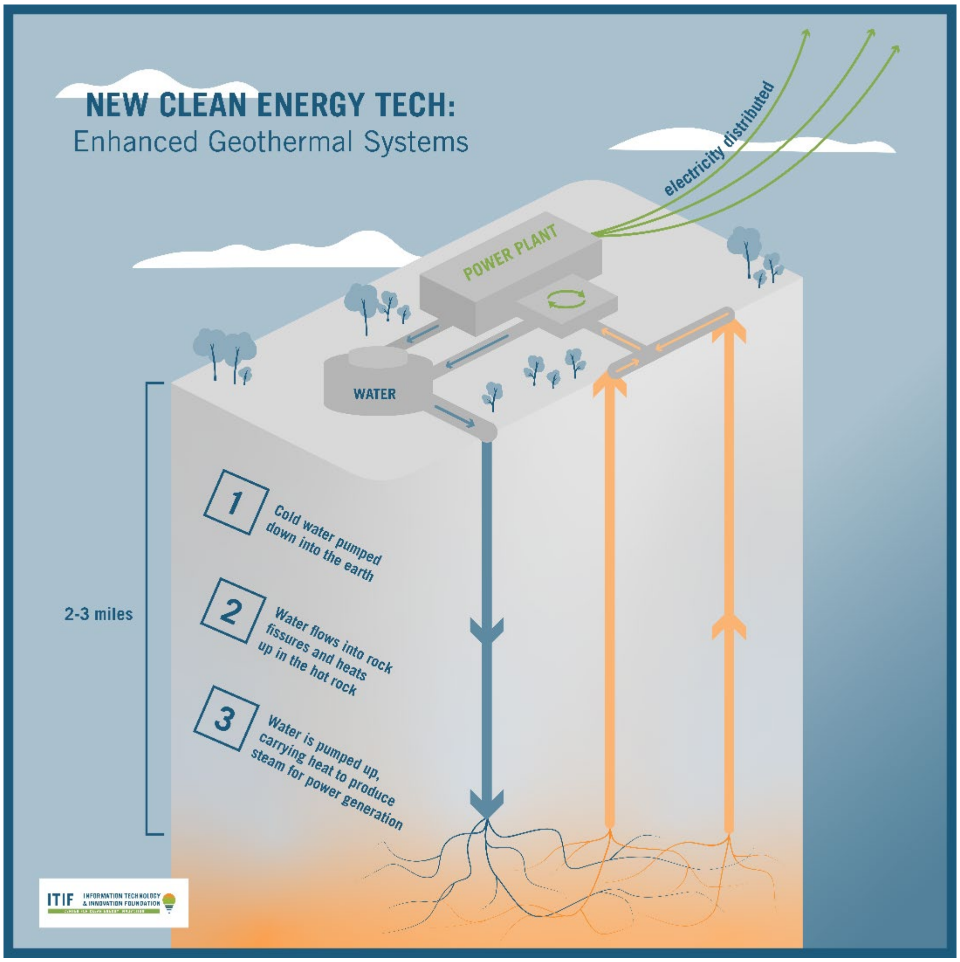
Climate-Tech to Watch

LINH NGUYEN | SEPTEMBER 2021 | ITIF.ORG/CLIMATE-TECH

WHAT ARE THEY?

An enhanced geothermal system (EGS) produces carbon-free power by harnessing the earth's heat from far below the ground. An EGS accesses the heat by injecting water at high pressure from wells on the surface. The water creates fractures in deep rock formations, and the rocks, in turn, heat up the water. The water is then pumped back up, carrying enough heat to produce steam for power generation. EGS promises to harness the inexhaustible heat of the earth's crust to help power the world for generations to come.

Figure 1: An enhanced geothermal system



EGS IN THE ENERGY TRANSITION

EGS would provide firm power around the clock while emitting little to no greenhouse gases, complementing intermittent renewables like wind and solar. The International Energy Agency's *Net Zero by 2050* report estimates that 126 gigawatts (GW) of additional geothermal capacity will be needed by 2050 to avert the worst impacts of climate change.[1] That's about 8 times as much capacity as the world has today. Most geothermal projects draw on conventional hydrothermal reservoirs—natural pockets of heat and water not far below the surface. However, only 2 percent of the earth's geothermal resources are available through such reservoirs.[2] Future capacity additions must come from EGS, which has the potential to provide 40 times the energy needed to achieve net-zero greenhouse gas emissions globally. [3]

But tapping into geothermal resources deep in the ground can be quite tricky. Current drilling technologies and techniques are not suitable for penetrating ultra-hot and dry rock formations, making the drilling process time-consuming and expensive. Elevated temperatures and corrosive environmental conditions deep beneath the surface can cause well-construction materials like steel to wear, and drilling electronics to melt. Next-generation high-temperature, high-pressure sensors, drilling tools, and well-casing materials are vital for EGS to become cost-competitive with other power-generation sources.

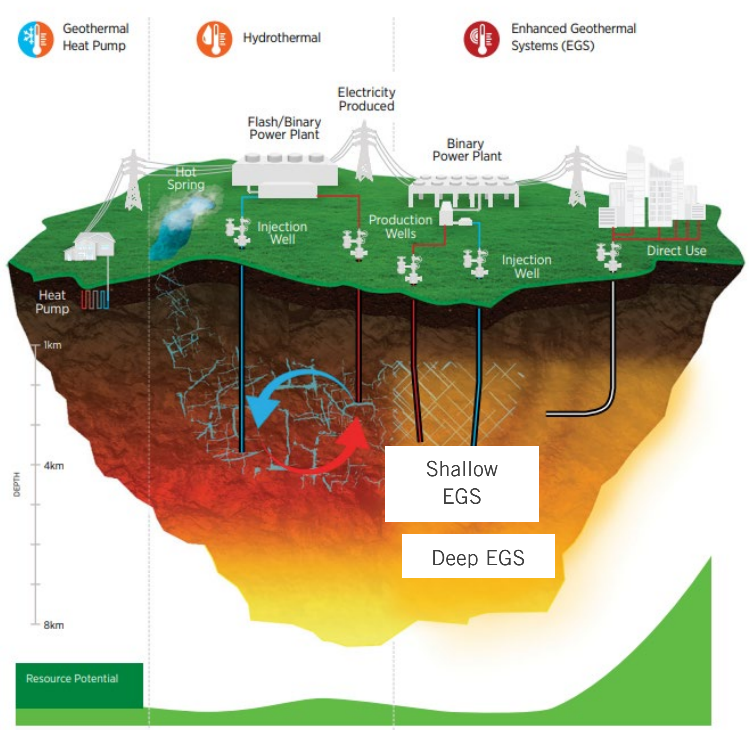
EGS RESOURCES

EGS includes a spectrum of resources—from shallow and low-temperature resources to as-yet unexplored very deep and very hot resources.

Shallow EGS resources are less than 10,000 feet deep and between 30°C and 150°C. Through EGS reservoir stimulation and engineering, they can be extracted from depleted wells at conventional hydrothermal sites or from areas a couple of thousand feet deeper that lack natural fluids. Improved technologies that can consistently and reliably capture shallow EGS resources could enable access to deep EGS.[4]

Deep EGS resources can reach up to 26,000 feet deep—18 times the height of the Empire State Building—with subsurface temperatures reaching over 400°C. Higher temperatures produce higher volumes of heat energy per well, along with increased efficiency. According to the geothermal company AltaRock, a 100 megawatt (MW) geothermal plant would require more than 40 wells operating at 200°C, but only 3 at 400°C.[5]

Figure 2: Diversity of geothermal resources and applications



GLOBAL PROGRESS

Only a handful of commercial EGS projects are operating today. Most of them are small and use EGS to extract power from shallow resources. Figure 3 shows the locations of 18 operating and planned EGS sites.[6] The oldest commercial EGS project currently generating power is at Soultz in Alsace, France. It began operations in 1987 and has an installed capacity of 1.7 MW. It has two enhanced reservoirs, one that is 10,000 feet deep and one 15,000 feet deep.[7]

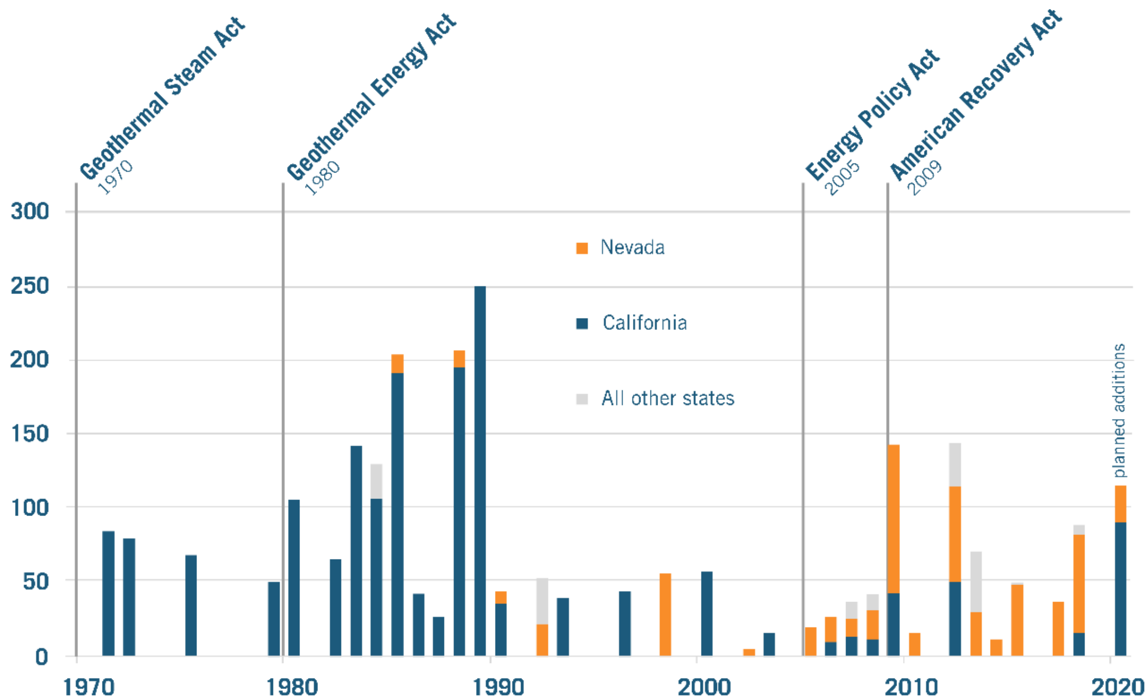
Figure 3: Global distribution of EGS sites

It's hard going. Many EGS projects have temporarily ceased operations or shut down due to drilling or plant operation issues, as well as reservoir creation and circulation challenges. These technical risks make EGS projects unattractive to private investors. Public funding for EGS demonstration projects is essential to drive down the cost and improve the reliability and performance of EGS projects to the point where risk-averse private investors will be willing to jump into this emerging industry.

PROGRESS IN THE UNITED STATES

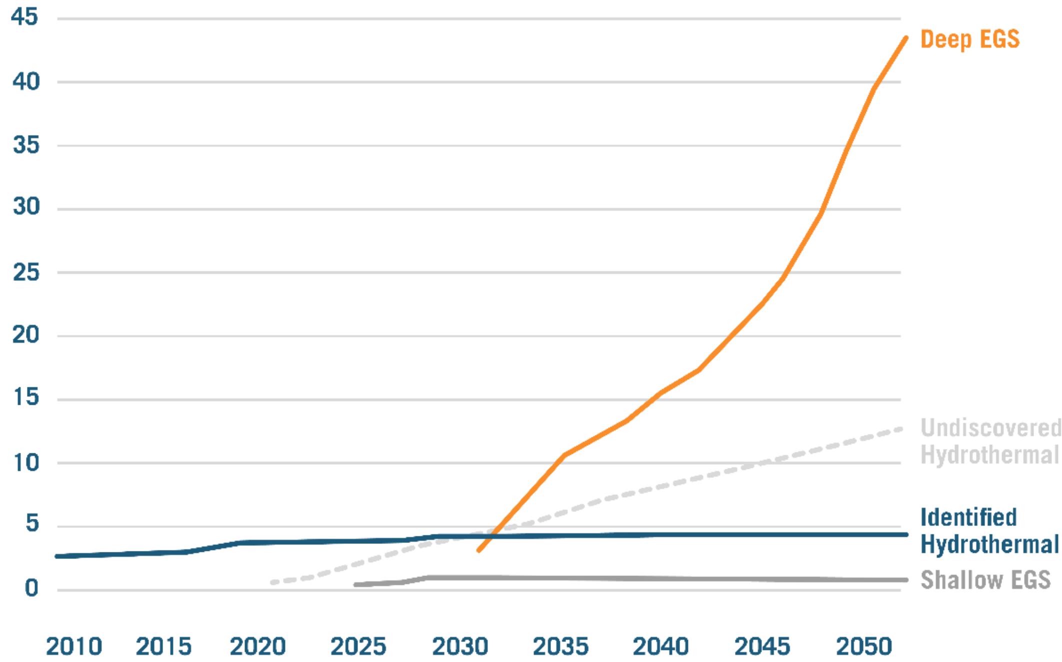
While the United States has more geothermal capacity than any other country, the U.S. EGS industry is in its infancy. Nearly half of existing U.S. geothermal power capacity came online in the 1980s following the Geothermal Energy Act, which improved geothermal project finance through loans and investment tax credits. The Energy Policy Act of 2005 led to a small increase in installed capacity through production tax credits and improvements in permitting processes. A much larger spike in installed capacity occurred in 2009 with the help of the American Recovery and Reinvestment Act, which included $350 million for geothermal demonstration projects; EGS research, development, and demonstration (RD&D); and innovative exploration techniques (see figure 4). Historical trends show federal investment in RD&D is critical to accelerating EGS deployment.

Figure 4: U.S. geothermal net capacity additions (MW) during peak summer demand (1971–2020)[8]



The U.S. Department of Energy (DOE) aided the EGS industry by funding a series of demonstration projects, including Ormat Technologies at Desert Peak, Nevada; AltaRock Energy at Bend, Oregon; the University of Utah at Raft River, Idaho; and Calpine Corporation at the Geysers, California.[9] These projects draw mostly on conventional shallow resources, leaving deep resources untapped. DOE estimates that, with technological innovation, 60 GW of domestic geothermal capacity could be added by 2050—20 times the current capacity—and most would come from deep EGS (see figure 5).

Figure 5: Geothermal installed capacity (GW) growth as predicted in *GeoVision* (2010–2050)[10]



KEY POLICY ISSUES

DOE plays an important role in funding EGS RD&D. DOE's key initiatives include the Frontier Observatory for Research in Geothermal Energy (FORGE), a dedicated site where scientists and engineers can develop, test, and accelerate breakthroughs in EGS and techniques, and EGS Collab, an in-situ field laboratory located at the Sanford Underground Research Facility in Lead, South Dakota. Additionally, DOE's Advanced Research Project Agency-Energy (ARPA-E) has funded several EGS projects, including AltaRock Energy's drilling technology for super-hot rock geothermal sites.

EGS technologies also have received strong support from Congress. The Energy Act of 2020 directs DOE to support up to three FORGE sites and demonstrate four EGS projects at sites that may be commercially viable across the nation. It authorizes $105 million for EGS demonstrations and $300 million for FORGE activities in fiscal years 2021 through 2025.[11] In addition, the bipartisan Infrastructure Investment and Jobs Act (H.R. 3684) authorizes an additional $84 million for EGS RD&D in fiscal years 2022 through 2025.[12]

The Interior Department's Bureau of Land Management (BLM) is responsible for permitting EGS sites on federal lands.[13] BLM is required to conduct a lengthy environmental review process under the National Energy Policy Act. In some cases, BLM also must seek approval from other federal agencies, such as the U.S. Forest Service, which may cause further delays and increase costs. Geothermal project development timelines can take as long as 7 to 10 years.

LOOKING FORWARD

EGS has the potential to supply the United States and the world with an inexhaustible, dispatchable, flexible source or renewable energy. With technological advancements in deep-well drilling and material improvements, EGS technology costs could be reduced, and geothermal energy could make substantial contributions to a net-zero energy system over the long term.

FURTHER READING

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About the Author

Linh Nguyen is a research assistant for clean energy innovation with ITIF. She previously worked for Climate Advisers and Resource Energy. She holds a master's degree in energy policy from Johns Hopkins University.

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ENDNOTES

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