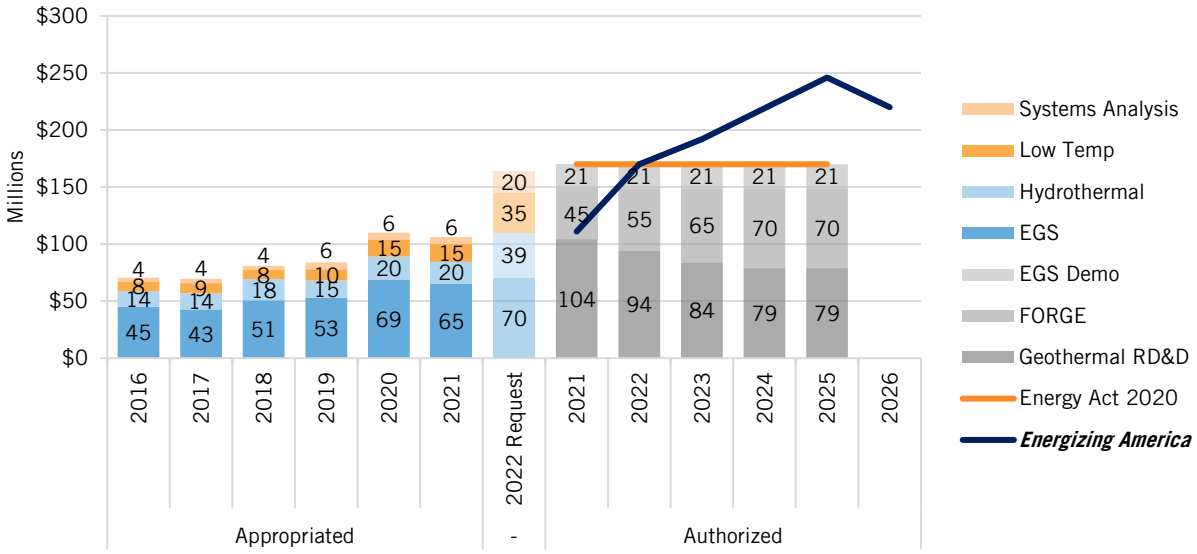
Federal Energy RD&D: Geothermal Technologies

BY COLIN CUNLIFF AND LINH NGUYEN | JUNE 2021

Geothermal technologies use heat from the earth, either directly for such applications as heating and cooling, or to generate electricity with steam turbines. The Geothermal Technologies program supports research, development, and demonstration (RD&D) of two main types of geothermal technologies: hydrothermal and Enhanced Geothermal Systems (EGS). Hydrothermal resources exist naturally in areas where there is sufficient temperature and permeability in the subsurface. EGS, on the other hand, requires rock stimulation for permeability enhancement and fluid injection to allow commercial-scale fluid flow that can be used for electricity generation.[1]

Figure 1: *Energizing America* recommends doubling investment in geothermal technologies by FY 2026.[2]



What's at Stake

There is a vast source of untapped energy that dwarfs the current U.S. installed capacity of about 3.8 gigawatts (GW) of geothermal energy. The Department of Energy's (DOE) 2019 report *GeoVision: Harnessing the Heat Beneath Our Feet,* finds that technological improvements and cost reductions could increase geothermal capacity more than fifteenfold to 60 gigawatts (GW) by 2050.[3] The geothermal industry operates in a harsh subsurface environment in which unique technical and operational challenges must be overcome in order to realize this potential. Foremost among these challenges is the resources essentially being "out of sight" at a depth of anywhere from 2 to 5 kilometers, thus requiring new exploration technologies and tools to reduce the near-term costs and risk of development. DOE set a goal of reducing the cost of electricity from EGS to 6 cents per kilowatt-hour ($0.06/kWh) by 2050, which would make this technology competitive with other forms of dispatchable baseload power.[4]

In addition, the United States has abundant low-temperature geothermal resources below 300 degrees F (150°C), with potential applications for residential and commercial heating and cooling, district heating and cooling, industrial process heating, and underground thermal energy storage. The *GeoVision* analysis finds that the market potential for geothermal heat pumps is equivalent to supplying heating and cooling to 28 million households, or 14 times more than the current installed capacity. Furthermore, district-heating geothermal systems could meet the heating and cooling demands of 45 million households in 2050.[5]

But realizing the enormous potential of America's domestic low-carbon geothermal resources requires RD&D to harness them more effectively, develop improved methods to stimulate new resources, and characterize and model subsurface stress and other reservoir properties. An increase in RD&D funding could enable DOE to unlock promising opportunities to advance geothermal technologies.

The Energy Act of 2020 provides the first reauthorization of DOE's Geothermal Technologies program in more than a decade. The law directs DOE to support the development of up to three Frontier Observatory for Research in Geothermal Energy (FORGE) sites to study EGS; requires DOE to demonstrate four EGS projects at potentially commercially viable locations across the nation; establishes a research program on geothermal heat pumps; directs the U.S. Geological Survey to update its geothermal resource assessments; and establishes a program that to advance geothermal computing and reservoir modeling. The Act authorizes $170 million annually for FY 2021 through FY 2025.[6] Of the total authorized funding, $21 million is authorized for EGS demonstrations annually for FY 2021 through FY 2025. FORGE activities are also authorized $45 million for FY 2021, $50 million for FY 2022, $65 million for FY 2023, $70 million for FY 2024, and $70 million for FY 2025 of the total authorized funding.

Figure 1 shows historical DOE investment in geothermal RD&D by subprogram, for FY 2016 through FY 2021, and the FY 2022 budget request. The orange line shows authorized funding levels from the Energy Act of 2020. The blue line shows recommended funding levels from the *Energizing America* report, which recommends doubling investment in geothermal RD&D by FY 2026 (see box 1).

Box 1: An Innovation Agenda for Geothermal

The *Energizing America* report co-authored by the Information Technology and Innovation Foundation (ITIF) and Columbia University's Center on Global Energy Policy offers several recommendations to accelerate innovation in geothermal technologies. Similarly, ITIF's December 2020 report "An Innovation Agenda for Advanced Renewable Energy Technologies" makes recommendations to DOE and Congress:

- Congressional appropriators should provide full funding to develop the three FORGE pilot sites and the four EGS demonstration projects that were authorized in the Energy Act of 2020.
- Congress should direct the Geothermal Technologies Office to expand RD&D collaboration with DOE's Office of Fossil Energy to develop technologies and processes using

unconventional oil, gas drilling, and simulation techniques to address the technical challenges of EGS.[7]

- Congress should provide additional funding for geothermal RD&D of geothermal heat pumps and district heating systems through prize competitions or cost-share programs.[8]
- Congress and DOE should support the development of high-temperature laboratory facilities to enable super-hot-rock EGS testing.[9]
- DOE should collaborate with private companies through cost-share agreements to build commercial EGS demonstration projects.[10]

Geothermal Technologies RD&D Subprograms

Geothermal RD&D is divided into four subprograms:[11]

- **Enhanced Geothermal Systems** explores materials and technologies to produce energy from man-made reservoirs that are otherwise not economical due to lack of water or permeability. Major initiatives include the EGS Collab, a small-scale field site in South Dakota for reservoir-model prediction and validation, and the FORGE site in Utah, a facility wherein industry and government researchers can test and validate innovative EGS technologies in a deep-rock environment.[12]
- **Hydrothermal Research and Development (R&D)** focuses on technologies necessary to find and access "blind" conventional hydrothermal resources—or geothermal resources that require little-to-no stimulation to improve permeability and fluid flow, and are without clear surface expressions—by targeting innovative approaches to microhole drilling applications, self-healing cements, and subsurface imaging.
- **Low-Temperature and Coproduced Resources** targets RD&D on technologies applicable to geothermal resources below a temperature of 300°F (150°C), including direct use of thermal resources for process- and space-heating applications; hybrid power designs that can be codeveloped with existing well-field infrastructures; and geothermal-enabling technologies, including thermal desalination processes and thermal energy storage.
- **Data, Modeling, and Analysis** focuses on identifying and addressing barriers to geothermal adoption, as well as validating and assessing technical progress to inform the direction and prioritization of the portfolio. [13]

Key Elements of the FY 2022 Budget Proposal[14]

The budget proposal seeks $163.76 million for the geothermal technologies program, a 54 percent boost from FY 2021 enacted levels. Some highlights include:

- **Decrease in funding for the Frontier Observatory for Research in Geothermal Energy (FORGE),** DOE's flagship geothermal research facility in Milford, Utah, aimed at developing and piloting EGS technologies. No funding is requested for Advanced Wellbore Completions for EGS Longevity, which focuses on alternative completion techniques. Funding is

requested for an additional competitive R&D solicitation on new EGS technologies and techniques.

- **An 8 percent increase in the EGS subprogram**, including increased funding for exploration and characterization R&D, which supports the near-field EGS demonstration projects and a prize competition to develop geophones that can reliably track reservoir growth during EGS simulations under high temperatures. The request also includes funding to establish the Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE), a consortium to leverage oil and gas assets and expertise to the geothermal field.
- **A 96 percent increase in the Hydrothermal subprogram,** including new funding for the Drilling Technology Demonstration Campaign, which will enable field demonstrations of innovative drilling technologies, including those adapted from the oil and gas industry, to reduce the costs and risks of drilling and attract future private investment and use.
- **A 131 percent increase in the Low Temperature subprogram,** including funding for the Energy Storage Grand Challenge to validate and demonstrate new thermal energy storage technologies; initial funding for the Community Geothermal Heating and Cooling Technical Assistance and Deployment initiative to demonstrate and deploy community-scale direct-use geothermal energy systems; for the Federal Partnerships for Geothermal Installations initiative, in collaboration with the Federal Energy Management Program, to drive geothermal projects on Federal sites; and for the Next Generation Connected Communities initiative, in collaboration with the Building Technologies Office, to demonstrate geothermal energy storage and community geothermal energy resource.
- **A 226 percent increase in the Data, Modeling, and Analysis subprogram,** including funding for geothermal-specific grid research and analysis.

Further Reading

- Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), http://www2.itif.org/2020-energizing-america.pdf.
- Robert Rozansky, "An Innovation Agenda for Advanced Renewable Energy Technologies" (ITIF, 2020), http://www2.itif.org/2020-advanced-renewables-energy.pdf.
- Robert Rozansky and Faith Smith, "Harnessing Heat: How the Federal Government Can Advance Geothermal Energy" (ITIF, 2020), http://www2.itif.org/2020-cp-itif-white-paper-harnessing-heat.pdf.

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ENDNOTES

1. U.S. Department of Energy (DOE), "FY 2021 Congressional Budget Justification" Volume 3 Part 1, 141–160 (DOE Chief Financial Officer DOE/CF-0163, February 2020), https://www.energy.gov/sites/prod/files/2020/02/f72/doe-fy2021-budget-volume-3-part-1.pdf.
2. Varun Sivaram et al., *Energizing America: A Roadmap to Launch a National Energy Innovation Mission* (ITIF and Columbia University SIPA Center on Global Energy Policy, 2020), 115, http://www2.itif.org/2020-energizing-america.pdf.
3. DOE, "GeoVision: Harnessing the Heat Beneath Our Feet" (DOE EERE, June 2019), p. xii. https://www.energy.gov/eere/geothermal/downloads/geovision-harnessing-heat-beneath-our-feet.
4. DOE's cost goal for geothermal systems is unclear. The "Fiscal Year 2017 Annual Performance Report/Fiscal Year 2019 Annual Performance Plan" states a goal of $0.06/kWh by 2030, which "includes both hydrothermal and Enhanced Geothermal Systems." However, the Fiscal Year 2021 Congressional Budget Justification states a goal of $0.06/kWh by 2050 "from newly developed enhanced geothermal systems." This cost goal in the FY 2021 Congressional Budget Justification appears to reflect a reduction in ambition. DOE, "Fiscal Year 2017 Annual Performance Report/Fiscal Year 2019 Annual Performance Plan," 82 (DOE/CF-0147), https://www.energy.gov/sites/prod/files/2018/11/f57/fy-2017-doe-annual-performance-report-fy-2019-annual-performance-plan.pdf; DOE, "FY 2021 Congressional Budget Justification," Volume 3 Part 1, 145–153.
5. DOE, "GeoVision: Harnessing the Heat Beneath Our Feet," p. xiii.

6. Consolidated Appropriations Act, 2021, Division Z, Sec. 3004, https://rules.house.gov/sites/democrats.rules.house.gov/files/BILLS-116HR133SA-RCP-116-68.pdf.
7. ITIF, "Harnessing Heat: How the Federal Government Can Advance Geothermal Energy," 12, http://www2.itif.org/2020-cp-itif-white-paper-harnessing-heat.pdf?_ga=2.129078213.831060285.1615309822-1615910346.1611086159
8. Ibid.
9. Ibid.
10. Robert Rozansky, "An Innovation Agenda for Advanced Renewable Energy Technologies" (ITIF, 2020), 22, http://www2.itif.org/2020-advanced-renewables-energy.pdf.
11. DOE, "Geothermal Technologies Office 2017 Annual Report," 3 (DOE EERE, January 2018), https://www.energy.gov/sites/prod/files/2018/01/f47/GTO%202017%20Annual%20Report.pdf; DOE, "FY 2021 Congressional Budget Justification" Volume 3 Part 1, 145–160.
12. Alexis McKittrick et al., "Frontier Observatory for Research in Geothermal Energy: A Roadmap" (IDA Science and Technology Policy Institute, February 2019), https://www.ida.org/idamedia/Corporate/Files/Publications/STPIPubs/2019/D-10474.pdf.
13. DOE, "FY 2021 Congressional Budget Justification," Volume 3 Part 1, 145–153.
14. DOE, "FY 2022 Congressional Budget Justification" Volume 3 Part 1, 303, (DOE Chief Financial Officer DOE/CF-0173, June 2021), 351-378, https://www.energy.gov/sites/default/files/2021-06/doe-fy2022-budget-volume-3.1-v2.pdf.