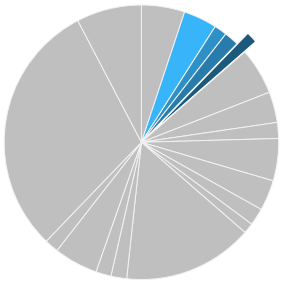
Federal Energy R&D: Geothermal Technologies

BY COLIN CUNLIFF | APRIL 2019

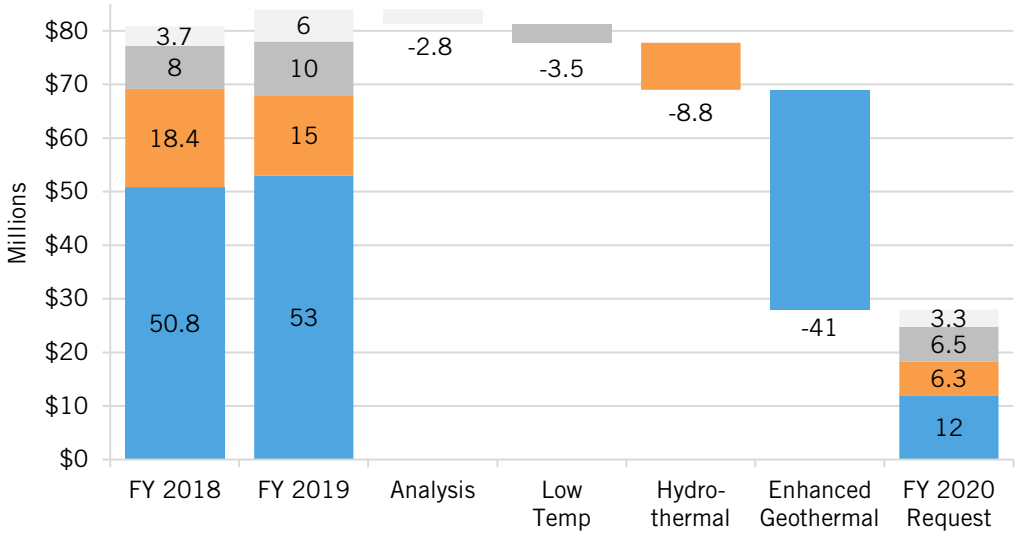
This briefing is part of a series on the U.S. energy budget. See: itif.org/energy-budget.



Geothermal (blue)
Other Renewables (blue)
Energy R&D (light grey)

Geothermal technologies use heat from the earth, either directly for such applications as heating and cooling, or to generate electricity. The Geothermal Technologies program supports research and development 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 for the flow of fluids to generate electricity. 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: The FY 2020 budget request would cut geothermal R&D by 67 percent.[2]



What's At Risk

In addition to the current U.S. installed capacity of geothermal energy of over 3.7 gigawatts (GW), there is a vast source of untapped energy just waiting to be realized: an estimated 30 GW of hydrothermal plus more than 100 GW of geothermal energy through EGS.[3] The geothermal industry operates in a harsh subsurface environment in which unique technical and operational challenges must be overcome to realize this potential. Foremost among these challenges is the resources essentially being "out of sight" at a depth of anywhere from two to five kilometers, thus requiring new exploration technologies and tools to reduce the near-term cost and risk of development. DOE has set an ambitious goal

of reducing the cost of electricity from newly developed geothermal systems from 22 cents per kilowatt-hour ($0.22/kWh) in 2017 to $0.06/kWh by 2030.[4]

In addition, the United States has abundant low-temperature geothermal resources below 300 °F (150 °C), with potential applications for district heating and cooling, industrial process heating, and underground thermal energy storage. A recent U.S. Geological Survey assessment identified 46.5 GW thermal (GWth) of renewable heat could be extracted from geothermal resources below 200 F (90 C).[5]

But realizing the enormous potential of America's domestic low-carbon geothermal resources requires R&D to harness these resources more effectively, develop improved methods to stimulate new resources, and characterize and model subsurface stress and other reservoir properties. DOE's Geothermal Technologies Office is currently preparing the *GeoVision Study*, to be released in early 2019, to identify gaps in our understanding of the potential of geothermal resources and to inform DOE's R&D priorities as it seeks to reduce costs and increase access to geothermal resources.[6] Reductions in R&D funding threaten DOE's ability to take advantage of the most promising opportunities to advance geothermal technologies.

Geothermal Technologies R&D Subprograms

Geothermal R&D is divided among four subprograms:[7]

- **Enhanced Geothermal Systems (EGS)** explores materials and technologies to produce energy from man-made reservoirs that are otherwise not economical due to lack of water and/or permeability. Major initiatives include the EGS Collab, a small-scale field site in South Dakota for reservoir model prediction and validation, and the Frontier Observatory for Research in Geothermal Energy (FORGE) site in Utah, a facility where industry and government researchers can test and validate innovative EGS technologies in a deep rock environment.[8]

- **Hydrothermal R&D** focuses on technologies necessary to find and access "blind" conventional hydrothermal resources—geothermal resources that require little-to-no stimulation to improve permeability and fluid flow but 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.

- **Systems 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.

Key Elements of the FY 2020 Budget Proposal

- **A 77-percent decrease in the EGS subprogram**, including a $25 million cut to FORGE, as well as the use of previously-appropriated funding to conduct FY 2020 activities; no new funding for the EGS Collab; no new funding for additive manufacturing efforts at ORNL that would facilitate low-cost drilling; no new funding to support the Efficient Drilling for Geothermal Energy (EDGE) program; and no new funding opportunities / open laboratory calls to conduct high-impact EGS R&D. The proposal includes a new $6.7 million FORGE Wells of Opportunity activity to fund EGS stimulation R&D at available unused geothermal wells prior to testing at FORGE.

- **A 58-percent reduction in the Hydrothermal subprogram**, including a reduction in subsurface R&D to develop technologies to characterize and monitor subsurface stress; no new funding to support the Efficient Drilling for Geothermal Energy (EDGE) program; and no new funding opportunities / open laboratory calls to conduct high-impact hydrothermal R&D.

- **A 35-percent reduction in the Low Temperature subprogram,** including no new funding opportunities / open laboratory calls in novel low-temperature geothermal R&D and no new funding on critical mineral recovery from geothermal brines. The proposal would pivot R&D activities to focus on subsurface thermal energy storage as part of the administration's crosscutting Advanced Energy Storage Initiative.

- **A 46-percent decrease in the Systems Analysis subprogram**, including no new funding opportunities / open laboratory calls in geothermal systems analysis, and a new activity to identify non-technical barriers in geothermal market penetration.

ENDNOTES

1. DOE, "FY 2020 Congressional Budget Justification" Volume 3 Part 2, 149-162 (DOE Chief Financial Officer DOE/CF-0153, April 2019), https://www.energy.gov/sites/prod/files/2019/04/f61/doe-fy2020-budget-volume-3-part-2.pdf.
2. The FY2020 budget for EERE would use $353 million in prior year (FY 2018 and FY 2019) balances to fund FY2020 programs. Thus the numbers shown in the figure underestimate the magnitude of cuts included in the proposed budget. Department of Energy, "FY 2020 Congressional Budget Request: Budget in Brief," (DOE CFO, March 2019), p 3, https://www.energy.gov/sites/prod/files/2019/03/f60/doe-fy2020-budget-in-brief.pdf; DOE, "FY 2020 Congressional Budget Justification" Volume 3 Part 2, 150.
3. EIA, Form EIA-860, table 3.1, (release date: September 13, 2018), https://www.eia.gov/electricity/data/eia860/; USGS, "Assessment of Moderate- and High-Temperature Geothermal Resources of the United States," (Washington, DC: USGS, 2008), https://pubs.usgs.gov/fs/2008/3082/pdf/fs2008-3082.pdf.
4. DOE's cost goal for geothermal systems is unclear. The "Fiscal Year 2017 Annual Performance Report / Fiscal Year 2019 Annual Performance Plan" states the goal of $0.06/kWh by 2030, although the goal

"includes both hydrothermal and Enhanced Geothermal Systems." However, the Fiscal Year 2020 Congressional Budget Justification states the goal of $0.06/kWh by 2050 "from newly developed enhanced geothermal systems" and also includes a separate goal of $0.09/kWh by 2022 "from currently undiscovered hydrothermal resources." The goals in the FY 2020 Congressional Budget Justification appear 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 2020 Congressional Budget Justification" Volume 3 Part 2, 153-157.

5. Colin F. Williams, Jacob DeAngelo, and Marshall J. Reed, "Revisiting the Assessment of Geothermal Resources <90 °C in the United States," *Transactions* Vol. 39 (Geothermal Resources Council, 2015) http://pubs.geothermal-library.org/lib/grc/1032137.pdf.
6. According to DOE's website, it anticipates release of the *GeoVision* analysis findings in early 2019: DOE, "GeoVision" https://www.energy.gov/eere/geothermal/geovision, accessed April 5, 2019. Some of the analysis supporting the GeoVision study has already been published. See, for example, Thomas S. Lowry et al., "GeoVision Analysis Supporting Task Force Report: Reservoir Maintenance and Development" (Sandia National Laboratories, September 2017), https://doi.org/10.2172/1460735; and Christine Doughty et al., "GeoVision Analysis Supporting Task Force Report: Exploration" (Lawrence Berkeley National Laboratory, June 2018), https://doi.org/10.2172/1457012.
7. 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.
8. 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.

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