CARBON FREE
TECHNOLOGY INITIATIVE

CFTI FY2024 + Superhot Rock and EGS Recommendations

Geothermal energy technology is operating today, mining heat from natural and enhanced hydrothermal systems, which produce steam from circulating groundwater in regions where the crust is hot, such as near volcanoes, hot springs, or thin crust.

What are engineered geothermal systems? Engineered geothermal systems (abbreviated EGS), a maturing geothermal technology, emulates hydrothermal systems by injecting water into engineered reservoirs of hot dry rock to produce steam or supercritical water at the surface to generate power. These systems utilize production methods similar to legacy oil and gas systems and hold much promise for clean firm power. According to a 2023 NREL report, by 2050, over 90GWe can be produced from conventional EGS systems that take advantage of deep hot dry rock resources spread throughout various regions of the country. However substantial investment in it is needed now to de-risk the engineering technology required to bring the systems to full deployment.

What is Superhot Rock? Superhot rock (SHR) geothermal energy is the hottest type of EGS system that takes advantage of very energy-dense geothermal resources at depths where temperatures exceed 400°C and where water, either natural or injected, is in a supercritical state with more energy content and much greater fluidity. By accessing these deeper, hotter resources, SHR geothermal could produce ten times the energy per well compared to conventional geothermal or EGS, giving it the potential to be competitive in the power market. The potential of SHR is vast, scalable, and builds on existing industries for drilling and power production, recent innovations and increasing interest from venture capital firms. Additionally, SHR geothermal will not be geographically restricted, unlike today's commercial geothermal power. Additional benefits of SHR geothermal include a small footprint, high energy density, the potential for siting at existing and/or shuttered fossil fuel plants, and the ability to contribute to the production of zero-carbon hydrogen.

We focus here on systems that have the potential to produce zero carbon power anywhere, and by necessity this requires the development of drilling, and reservoir development in hot dry rock geologic settings. When we refer to EGS we mean all geothermal power development in hot dry rock in temperatures below approximately 400°C. In contrast we refer to geothermal systems above 400°C as superhot rock (abbreviated SHR). This distinction is important for demonstration and R&D purposes because superhot rock utilizes water in a supercritical state which is a very different working fluid than hot water or steam. Moreover, our SHR focus is premised on the potential to produce 5 to 10 times the energy per well giving it the potential to be cost competitive, and energy dense with the possibility to replace fossil power. Nonetheless, the lower temperature systems, particularly in the range above approximately 200° C could have the potential to help unlock technologies needed to access SHR resources. Continuing to develop and improve conventional EGS systems will be useful in expediting our clean energy transition especially in the Western United States. However, the future potential SHR holds in bringing competitive, clean, firm, and extremely power dense systems to anywhere in the country will revolutionize our relationship with energy. Therefore, as outlined below CFTI supports both approaches.

Policy Considerations

CFTI believes that de-risking SHR and EGS technologies is essential to lay the groundwork for private investment. The oil and gas industry has the subsurface know-how and foundational technologies to move SHR and other EGS projects to commercial scale. Bridging the gap and providing research and development funds that build on those technologies for geothermal purposes could provide terawatts of clean, firm alternatives to fossil energy for tomorrow's utilities, transforming the grid.

The Energy Act of 2020 and Infrastructure Investment and Jobs Act (IIJA) took initial steps to help develop EGS technologies, specifically by supporting a newly announced $74 million program to fund up to seven commercial scale EGS pilot demonstration projects, including SHR where the heat is at accessible (relatively shallow: 4-7 km) depths. However, this program is only for demonstrating new pilot projects, significant levels of research and development funding are still needed to de-risk and move SHR and EGS to commercial scale – including solving engineering challenges in developing energy dense power systems in deep hot rock. While the annual funding provided to the DOE's Geothermal Technologies Office (GTO) has been helpful, larger amounts are needed to truly de-risk technologies and spur the large-scale deployment efforts necessary to reap the climate and economic benefits of the industry. For context, amounts enacted in recent Federal Appropriations bills (fiscal years 2017-2023) for GTO are listed below. With these meager levels of funding, it is not possible to underpin ambitious geothermal drilling and engineering initiatives that could lead to geothermal technology breakthroughs.

Amount Enacted
FY23: Geothermal Technologies: $118,000,000
FY22: Geothermal Technologies: $109,500,000
FY21: Geothermal Technologies: $106,000,000
FY20: Geothermal Technologies: $110,000,000
FY19: Geothermal Technologies: $84,000,000
FY18: Geothermal Technologies: $80,906,000
FY17: Geothermal Technologies: $69,500,000

In order to reach the necessary levels of generation capacity, public/private funding levels similar to those invested for nuclear, hydrogen, and CCS technologies –billions--will be required. For this reason, we recommend far more ambitious R,D&D support for SHR and engineered geothermal systems in hot dry rock—amounts in the billions over 5 years. CFTI requests funding levels for programs on par with other zero carbon energy technologies as follows:

FY24 (CFTI Recommended Levels for Current and New Program Authorizations)	FY24-28 (CFTI Approximate Projected Recommended Levels for Current and New SHR Program Authorizations with Notional Increases*)
$435M for GTO as follows: $200M Superhot Rock $100M EGS $100M FORGE $35M GEODE	**$3.155B over 5 years for GTO as follows:** $1.5B Superhot rock $1.0B EGS $500M FORGE $155M GEODE

*FY24-28 annual funding request breakdown:
SHR: 2024: $200M, 2025: $300M; 2026: $300M; 2027: $300M; 2028: $400M
EGS: 2024: $100M, 2025: $150M; 2026: $200M; 2027: $250M; 2028: $300M
FORGE: 2024: $100M, 2025: $100M; 2026: $100M; 2027: $100M;2028: $100M
GEODE: 2024: $35M, 2025: $40M, 2026: $40M, 2027: $40M

GTO Research, Development and Demonstration Program Funding Recommendations

- **Superhot Rock**

CFTI envisions a GTO superhot rock geothermal stand-alone initiative that aims to enable pilot drilling projects and advanced engineering (including new innovative drilling technologies that can reach great depth (e.g. 10- 20 km), such as energy drilling (plasma and millimeter wave), reservoir creation in the brittle-ductile zones of the lower crust, adaptation of downhole tools and well construction materials and methods) for mixed-phase supercritical water, temperatures greater than 400C at high pressures.

- Support multi-year demonstrations starting in 2024 for superhot reservoir creation and advanced drilling pilot demonstrations for: a) fully integrated SHR power projects, a) advanced drilling with supercritical water resource production, and c) ultra-deep drilling initiative, for example to exceed 12km into supercritical conditions.
- Provide cost share partnerships and national laboratory support for the research and development of technologies that advance the technology readiness of superhot rock energy as follows:
    - Support for both laboratory and field-based research and laboratory engagement with private industry.
    - Establish programs to support innovative approaches to reservoir creation, addressing induced seismicity, advancing ultradeep drilling combined with focus on supporting subsurface simulation, monitoring, downhole sensors, and de-risking other production dependencies that can be leveraged both for SHR and other high enthalpy EGS power systems. These dollars can be used to complement the FORGE drilling efforts.
    - A federal cost-share of 80 percent to encourage public-private collaboration and partnership.
    - Establish – through coordination between the United States Geological Survey and GTO an initiative focused on play fairway analysis to identify areas with high SHR and EGS resource potential.
    - Establish an initiative tasked with developing super-deep energy drilling and conducting field-based pilots to support and inform commercial-scale SHR geothermal demonstrations.
    - Commission investigative study reports such as:
        - Scale: Investigate the full potential of SHR energy and its ability to meet or exceed future global power demand.
        - Value: Develop a methodology to accurately value (e.g. LCOE) EGS firm renewable energy for utilities (considerations: carbon market, grid upgrades, RPS, etc).
        - Regulatory: Reviewing regulatory needs in cooperation with EPA in advance of commercialization such as seismic risk and groundwater protection.

  - Power Conversion: Investigating the engineering needs and potential to convert fossil EGUs to SHR.

- **Engineered Geothermal Systems**

The Geothermal Technology Office released a funding opportunity announcement on February 8, 2023, $74M in funding for EGS (and superhot rock) pilot demonstrations, building momentum for the GTO's "Geothermal Shot". While this funding will take great steps to deploying and demonstrate select innovative geothermal projects, base R&D funding must still rise to effective levels to expedite full market adoption of the industry. To advance the available funding for EGS field and laboratory programs to greater levels, CFTI recommends funding increases per year to support GTO operations and build funding for Pilot projects and EGS R,D&D including:

- Increasing funds available for multi-year pilot demonstrations starting in 2024 for drilling, reservoir creation and advanced drilling pilot demonstrations fully integrated EGS power projects.

- Supporting national laboratories to lead collaborative research and development of downhole remote sensing technologies adapted to temperatures greater than 175C temperatures where downhole tools at FORGE have been reportedly to fail.

- **Continuing the FORGE program**

The Geothermal Technology Office's Frontier Observatory for Research in Geothermal Energy (FORGE) program supports a dedicated field site in the Milford Valley Utah. From its web site (https://www.energy.gov/eere/geothermal/forge):

> *FORGE research and development (R&D) activities focus on strengthening our understanding of the key mechanisms controlling EGS success—specifically, how to initiate and sustain fracture networks in basement rock formations. This critical knowledge will be used to design and test a methodology for developing large-scale, economically sustainable heat exchange systems, paving the way for a rigorous and reproducible approach that will reduce industry development risk and facilitate EGS commercialization.*

- CFTI recommends $100M per year over 5 years for continuation of the Frontier Observatory for Research in Geothermal Energy (FORGE) drilling program. This successful GTO program requires more robust support for its ongoing field drilling activities, which is providing learnings and tool development that can benefit both EGS super-hot rock geothermal systems. FORGE also provides a platform for collaborative projects.

- **Fully Funding the GEODE Program.**

The U.S. Department of Energy Announced a new 5-year program in 2022 to form a consortium that will develop a roadmap for leveraging oil and expertise in geothermal energy. The Geothermal Energy from Oil and Gas Demonstrated Engineering (GEODE) program has four facets: 1) Technology Transfer, 2) Demonstrations and Deployment, 3) Analysis and Regulatory Barriers, 4) Workforce and Communications. (See: https://www.energy.gov/eere/geothermal/funding-notice-geothermal-energy-oil-and-gas-demonstrated-engineering-geode)

CFTI recommends:

- Appropriating the remaining $155M needed to fully fund the program, starting with $35M for FY24, and then $40M per year until FY27.

Additional Policy Recommendations

Deployment

- Establish a production or investment tax credit for SHR geothermal like those offered to wind and solar, with authorization through 2035 and options for monetization.
- Establish risk reduction tax incentives, such as tax write-offs for well failures, to help advance SHR geothermal drilling through more projects.
- Establish incentives for the production of supercritical steam from SHR projects.
- Establish incentives for the development and use of ultra-deep drilling. Such as energy drilling.
- Establish incentives for the co-production of hydrogen and critical minerals such as lithium in conjunction with EGS and SHR energy projects.
- Establish incentives for coproducing wells, utilizing geothermal resources discovered during oil and gas drilling activities.

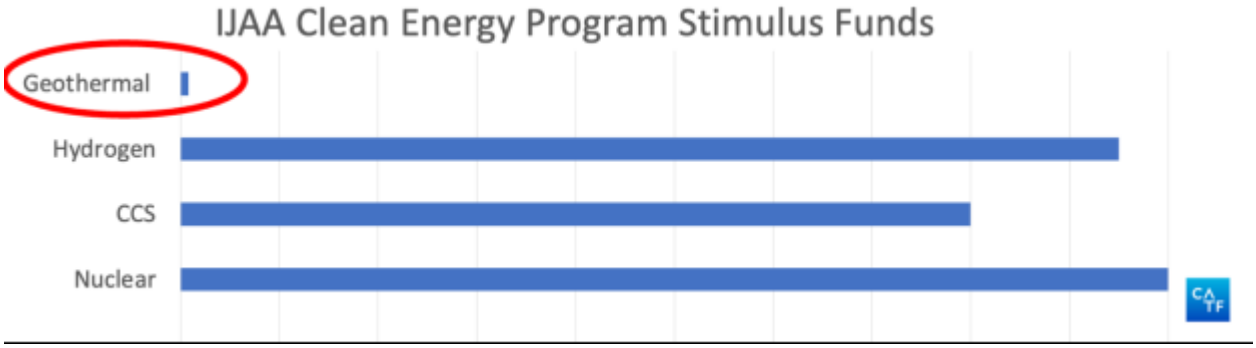
Regulatory Clarity

- Direct EPA to conduct a review and/or develop federal regulations in anticipation of SHR commercialization. Focus areas should include working with U.S. EPA and states to review EPA's Underground Injection Control rules (UIC) for protection of water resources and establish best practices and regulations for reservoir stimulation and for minimizing risk of induced seismicity.
- Direct federal agencies, including the Bureau of Land Management and the United States Forest Service, to assess how SHR project permitting on federal lands should be conducted and could be streamlined for faster approvals without sacrificing environmental integrity.
- Provide federal funding for states to develop geoscience expertise and oversight capabilities for permit review.

About the Carbon-Free Technology Initiative

The Carbon-Free Technology Initiative (CFTI) is focused on implementation of federal policies that can help ensure the commercial availability of affordable carbon-free, 24/7 power technology options by the early 2030s to help the electric power industry meet net-zero carbon reduction commitments. Participants and contributors to the CFTI geothermal review include the Edison Electric Institute (EEI) and its member companies such as Southern Company; NGO groups such as Clean Air Task Force, Third Way, the Bipartisan Policy Center, Center for Climate and Energy Solutions, ClearPath, and the Information Technology & Innovation Foundation.

For reference, illustrating the minimal funding resources adopted for geothermal in the recent IJAA compared to other clean energy technologies.



February 9, 2023