DOCKETED	
Docket Number:	21-ESR-01
Project Title:	Resource Planning and Reliability
TN #:	258556
Document Title:	Fervo Comments SB 423 Emerging Renewable and Firm Zero-Carbon Resources Report
Description:	N/A
Filer:	Amanda Cooey
Organization:	Ellison Schneider Harris & Donlan LLP
Submitter Role:	Applicant Representative
Submission Date:	8/16/2024 5:29:22 PM
Docketed Date:	8/16/2024

August 16, 2024

California Energy Commission

Reliability Analysis Branch

715 P Street

Sacramento, CA 95814

Dear Chair Hochschild, Vice Chair Gunda, Commissioners and Staff:

Fervo Energy (Fervo) appreciates the opportunity to provide public comment on the California Energy Commission (Commission or CEC) Draft Staff Report on SB 423 Emerging Renewable and Firm Zero Carbon Resources. Fervo thanks the Commission and Staff for advancing opportunities to enhance reliability as the state moves towards meeting its SB 100 goals. Fervo recognizes the CEC's role in the state's energy planning process in consultation with the California Public Utilities Commission (CPUC) and the California Independent System Operator (CAISO), especially as it concerns the integration of firm, baseload renewable energy sources into the state's electricity grid.

I. About Fervo Energy

Fervo is a developer of utility-scale enhanced geothermal systems (EGS) projects with lease holdings across the west, including California, and is actively developing projects to support the California grid, including the 400-megawatt Cape Station project in Beaver County, Utah. Cape Station will deliver its first phase of carbon-free electricity to the California grid in 2026 to support power purchase agreements (PPAs) with several California Load Service Entities (LSEs), including Southern California Edison (SCE), in response to the California Public Utility Commission's procurement order for 1,000 MW of firm, dispatchable geothermal energy no later than 2028.[1]

Fervo is at the forefront of utilizing advanced subsurface technologies and drilling techniques for the development of next-generation geothermal energy. Fervo's utility-scale pilot project, Project Red achieved commercial operation last year and is currently powering Google's data centers in Nevada.[2] The success of Project Red confirms that EGS is commercially viable and

[1] CPUC, D. 21-06-035 (2021), *available at,* https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M389/K603/389603637.PDF

[2] Fervo's commercial pilot became the most productive enhanced geothermal system in history after producing 3.5 MW of power during a 30 day well test earlier this year. On November 28, 2023 the project reached commercial operation, selling power to Google data centers in Nevada. *Available at* https://blog.google/outreach-initiatives/sustainability/google-fervo-geothermal-energy-partnership/

ready to scale.[3] EGS opens access to a massive set of new subsurface heat resources and increases the capacity of projects to harness them. Larger projects and more abundant resources mean that EGS is rapidly improving the geothermal industry's ability to deliver reliable power across the west.

The geothermal industry is currently undergoing a revolution of innovation. In part due to California's leadership on reliability and grid decarbonization, next-generation geothermal technologies are available to play a critical role in supporting a reliable and affordable carbon-free grid. Fervo is excited to work with the CEC to integrate these new clean firm technologies and resources into California's reliability planning processes to ensure a smooth and cost-effective pathway to a fully decarbonized grid.

II. Introduction

Fervo commends the CEC's focus on planning for a zero-emission energy future. SB 423 requires the CEC to identify commercially available firm zero-carbon resources that can bolster grid reliability while mitigating greenhouse gas emissions and pollutants. Fervo's operating commercial project in Nevada, and 400 MW project being drilled in Utah demonstrate that EGS is currently experiencing rapid innovation and deployment-led cost improvement on its way to delivering zero-carbon, 24/7 power to Californians by 2026. In this comment, Fervo addresses modeling EGS resources and recommends strategies for the CEC to consider in its energy planning. Ensuring the CEC provides accurate data and insights on firm zero-carbon baseload resources are critical inputs for California's reliability outlook.

III. Discussion

A. Fervo recommends that the Commission modify the EGS land use impacts to better reflect realities seen in the field.

Fervo commends the Commission's consideration of land use impacts for clean technologies as it is important to evaluate the holistic environmental, social, and economic effects of energy generation technologies. However, Fervo finds the Land-Use Intensity of Energy ("LUIE") metric for EGS to be extremely misaligned with our experience as the only developer of EGS technology. The report lists EGS as having a 2,143 ha/TWh/Year LUIE, differing substantially from traditional binary geothermal systems. Since EGS utilizes traditional binary systems at the

[3] The CEC's working definition of "firm, zero-carbon resources" are "resources or combination of resources that reliably produce zero-carbon electricity on demand, ensuring a consistent and stable power supply for extended periods and/or are eligible for the Renewable Portfolio Standard (RPS)."

surface, the Commission should clarify that there is a significant distinction between EGS and traditional binary geothermal systems in terms of land use requirements.

Geothermal energy is a carbon-free resource with the lowest land use requirements of any renewable energy source (see Figure 1). EGS has proved even more land efficient than any other geothermal energy source, and we have found our capacity density to be lower than previous estimates for the geothermal industry.

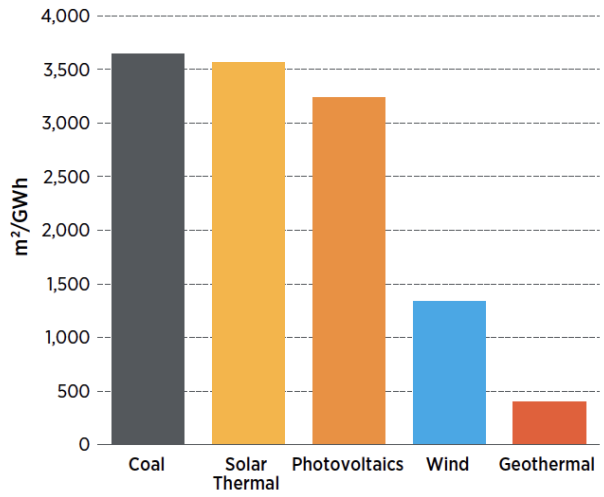

Figure 1: Land footprint by GWhe for various electricity-generation technologies
Source: Kagel et al. 2007

EGS-specific low land use impacts can largely be attributed to multilayer horizontal wells that utilize bench development. This 'wine rack' reservoir design illustrated in Figure 2 consists of drilling of horizontal wells within various stratigraphic intervals stemming from a single well pad. This approach is an extreme example of land optimization for energy production as it maximally utilizes the subsurface below any given well pad. This design maximizes energy production at each well pad which should decrease the Land Use Intensity of Energy (LUIE) metric. However, the CEC report reflects a vast and unexplained difference between the LUIE of traditional binary cycle plants (146 LUIE) and EGS binary cycle plants (2,143 LUIE).[4] Fervo strongly suggests that the Commission more closely examines this metric as it differs so vastly from our experience and provide explanation for this extreme variance.

[4] SB 423 Emerging Renewable and Firm Zero-Carbon Resources Report. 53.

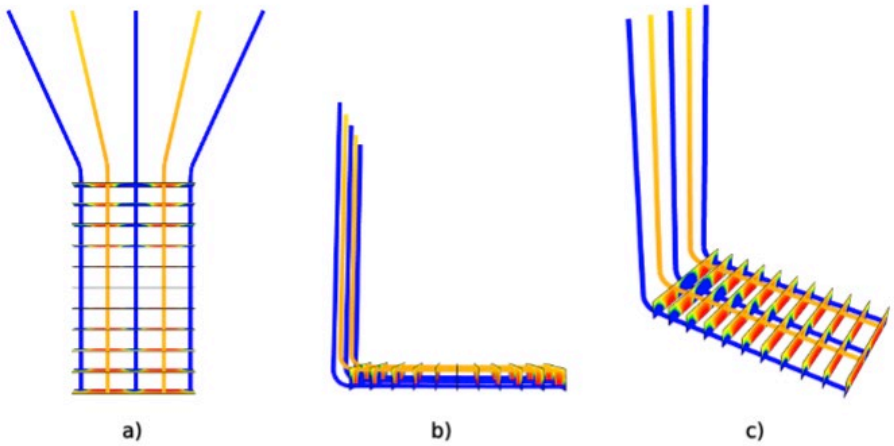

Figure 2: Vertical (a), horizontal (b), and diagonal (c) views of the at-scale EGS reservoir design. Production and injection wells are shown in orange and blue, respectively, and well laterals are connected by an engineered fracture network. For visual clarity, only every 15th fracture is shown.

Source: Ricks, W., Voller, K., Galban, G. et al. The role of flexible geothermal power in decarbonized electricity systems. Nat Energy (2024). https://doi.org/10.1038/s41560-023-01437-y

B. Fervo recommends modifications to EGS cost assumptions to reflect updated, publicly available resources.

The Commission's report, as it currently stands, reflects outdated inputs and assumptions by using NREL ATB 2023 data rather than NREL ATB 2024 data. We encourage the Commission to update their inputs and assumptions to reflect the NREL ATB 2024 data which has been adjusted to reflect changes especially critical for rapidly maturing industries such as EGS. NF EGS 2030 LCOE, for example, decreased by 56% in the conservative scenario between the 2023 and 2024 NREL ATB results. In fact, cost assumptions for NR EGS across all scenarios decreased. The Commission should update its assumptions for this important report to reflect the most current data on all technologies, especially maturing technologies.

Moreover, while the Commission's report reflects the DOE Pathways to Commercial Liftoff Report for long duration energy storage, it does not incorporate the cost reduction findings of the DOE Pathways to Commercial Liftoff Report for geothermal. In addition to praising geothermal's low land-use footprint, this report reflects a number of updated cost assumptions that greatly modernize geothermal planning and energy futures.

EGS improvements in the last several years have demonstrated how utilizing a modular approach to project development which unlocks improvements in cost, performance and scale. Modular

EGS projects apply replicable well designs across similar geologic conditions in a condensed area, paired with standardized surface facilities and generation equipment. This development approach produces learnings across all aspects of the project and results in continuous improvements in geologic, technical, and operational performance. Amongst geothermal technologies, these learning curves are unique to EGS, but they follow the same trajectory as learning-curve led cost declines in other renewable technologies such as solar and battery storage. EGS cost declines are rooted in engineering improvements gained through repetition and continual optimization, enabled by deployment across a massive available resource. This development process allows speed and scale previously unavailable to conventional geothermal development (See Figure 3).

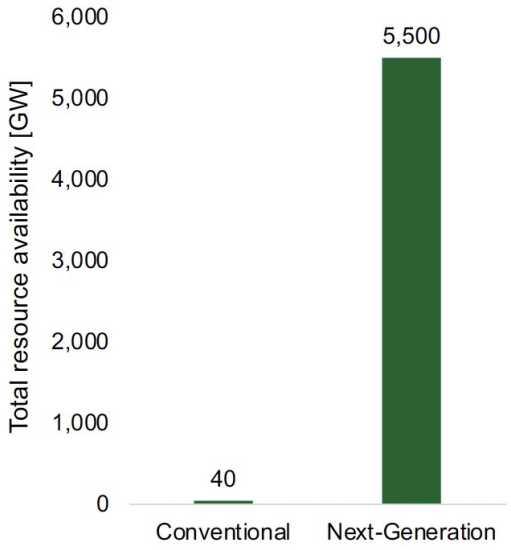

Figure 3: Comparison between total available resource for conventional geothermal (left) and next-generation geothermal (right).

Source: Pathways to Commercial Liftoff: Next-Generation Geothermal Power, U.S. Department of Energy.

EGS's learning curves are best observed through reduced drill times experienced in the field. The high cost of drilling has been a major driver of geothermal project economics and was thought to preclude EGS from the learning curves experienced by oil and gas industry during the shale revolution. Fervo's experience in the field, however, has demonstrated dramatic reductions in drill times attributable to learning-by-doing improvements. Since geothermal drilling costs can represent over half of total project costs and drilling time accounts for over 75% of total well cost, faster drilling is key to achieving cost declines. In February of 2024, Fervo published data from commercial drilling operations which show a 60% reduction in drilling days and a nearly

50% reduction in well costs (See Figure 4).[5] Fervo has continued to achieve drilling improvements beyond those presented, in addition to optimizing the replicability and capacity of our well designs.[6]

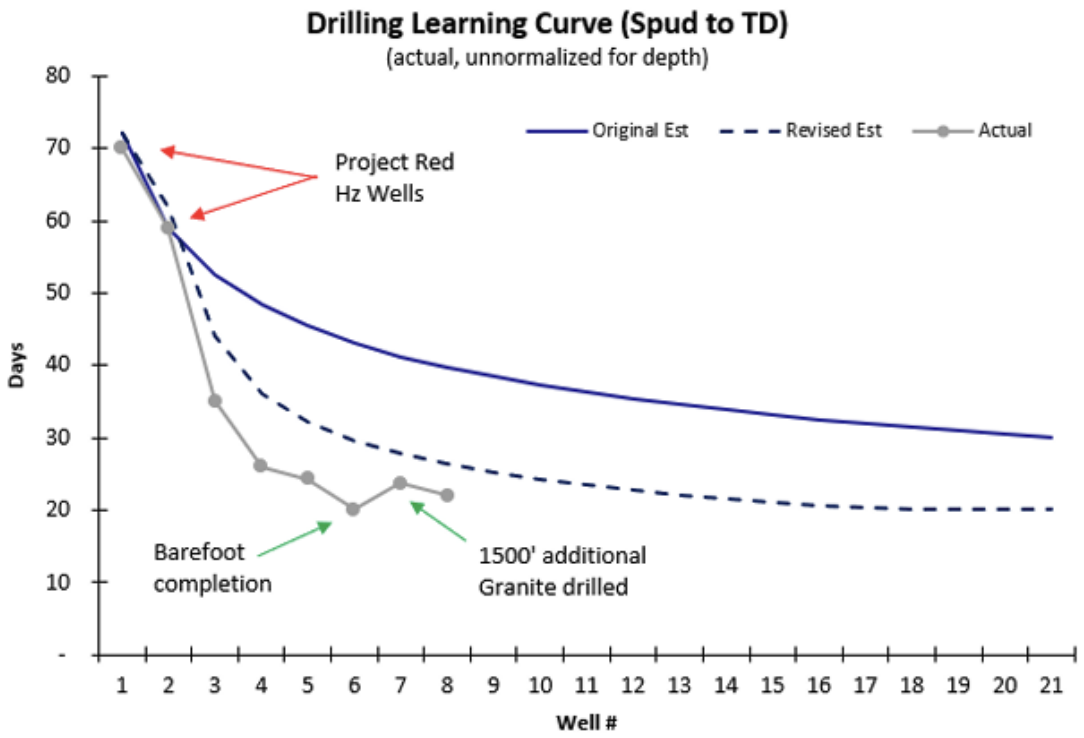

Figure 4: Fervo EGS Drilling Learning Curve (spud to actual TD) showing planning 18% learning curve and realized 35% learning curve across all EGS projects.
Source: El-Sadi et al. 2024

These iterative improvements enabled by advanced drilling operations have cut EGS drilling costs in half over the last two years. Reflecting these important advancements, NREL decreased the drilling costs for the Conservative Scenario for all technologies by 7% to match industry learnings. Projecting out along this demonstrated learning curve, the DOE suggests that the EGS Shot target of $45/MWh is achievable by 2035 (See Figure 5).[7]

[5] El-Sadi, K., Gierke, B., Howard, E., Gradl, C. 2024.
[6] El-Sadi, K., Gierke, B., Howard, E., Gradl, C. 2024.
[7] Blankenship, D., Gertler, C., Kamaludeen, M., O'Connor, M., Porse, S. 2024. 23.

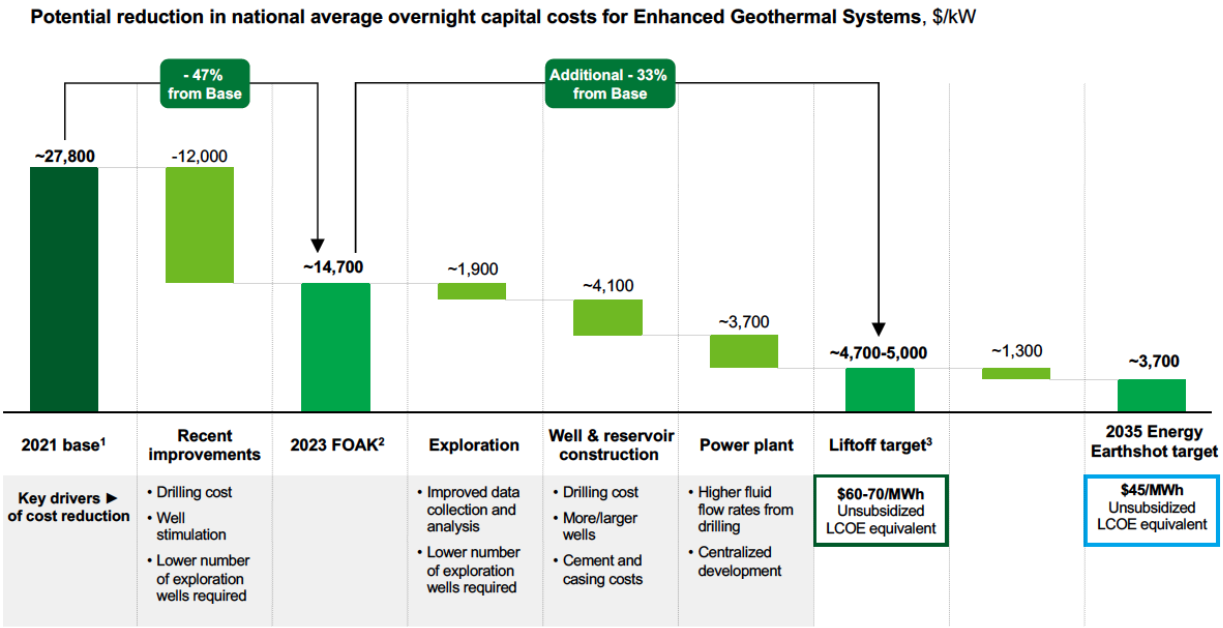

Figure 5: Cost reduction waterfall for EGS
Source: Pathways to Commercial Liftoff: Next-Generation Geothermal Power, U.S. Department of Energy; NREL ATB 2021 Base Case; NREL ATB Advanced Case; 2030 target based on trajectory to Energy Earthshot 2035 target.

C. Fervo recommends additional updates to the Commission's inputs and assumptions for this report.

In addition to important cost updates, several additional EGS assumptions have been updated in the Geothermal Electricity Technology Evaluation Model (GETEM), including the following as stated on the NREL 2024 ATB Geothermal update page:

- **Successful full-size exploration wells:** Remain at 2023 ATB values of five wells for Conservative, three for Moderate, and two for Advanced EGS scenarios.
- **Exploration drilling success rate:** Up from 76% to 80% and from 52% to 60% for the Moderate NF-EGS and Deep EGS scenarios, respectively. Up from 90% to 95% for both the Advanced NF-EGS and Deep EGS scenarios. This is based on horizontal well drilling successes in EGS projects in Nevada and Utah (Norbeck et al., 2023); (El-Sadi et al., 2024) and consultations with industry stakeholders.
- **Development drilling success rate:** Up from 76% to 80% for both NF-EGS and Deep EGS Moderate scenarios. Up from 90% to 95% for both NF-EGS and Deep EGS Advanced scenarios. This is based on horizontal well drilling successes in EGS projects in Nevada and Utah (Norbeck et al., 2023); (El-Sadi et al., 2024).

- **Stimulation success rate:** Updated from 75% (2023 ATB) to 80% (2024 ATB), 81% to 85%, and 90% to 95% for the NF-EGS and Deep EGS Conservative, Moderate, and Advanced scenarios, respectively, in accordance with industry trends (Norbeck and Latimer, 2023); (Pengju Xing et al., 2024).
- **Flow rate per production well**: Updated from 40 kilograms/second (kg/s) in the 2023 ATB to 60 kg/s for NF-EGS and Deep EGS Conservative scenarios to match recent industry trends (Norbeck et al., 2023); (Norbeck and Latimer, 2023).
- **Productivity/injectivity index:** Updated productivity and injectivity indexes from 2023 ATB values to match reservoir performance levels required for commercial operations (Norbeck and Latimer, 2023). See table below.
- **Plant size:** Aligned the baseline plant sizes of Deep EGS (flash and binary) with the NF-EGS values. Increased the 2023 ATB EGS Binary Moderate plant sizes from 30 megawatts-electric (MWe) (NF-EGS) and 25 MWe (Deep EGS) to 40 MWe each to account for trends in commercial field development plans.[8]

Fervo implores the commission to integrate these important findings into their report to assure continuity with the most up-to-date publicly available resources. Integrating these findings will be essential to adequately update measures to bolster the reliability and resiliency of California's electrical grid consistent with the state's emissions reduction goals.

D. Fervo recommends that the Commission consider geothermal resources being developed out of state which serve California through energy imports.

Maintaining continuity with the goals of SB 423 in assuring reliability and resiliency of California's grid, the Commission should consider geothermal projects outside of California as a part of the Geothermal Project Pipeline.[9] As our energy systems grow to accommodate an influx of intermittent renewable energy resources clean-firm power to accommodate for misaligned supply and demand curves, interregional energy planning must take priority if California is to plan for a renewable and reliable future. Omitting out-of-state projects from California's planning leaves a major hole in reliability planning that should be remedied by inclusion of all geothermal projects that are contracted with California LSEs.

IV. Conclusion

EGS is poised to transform California's energy landscape with abundant 24/7 clean energy from resources within the state and across the west. By integrating EGS into the state's renewable energy portfolio, California can achieve a more sustainable, reliable, and cost-effective energy future. Technological advancements in EGS, learning curves, dramatically declining costs, and

[8] 2024 NREL ATB Geothermal. https://atb.nrel.gov/electricity/2024/geothermal.
[9] SB 423 Emerging Renewable and Firm Zero-Carbon Resources Report. E-2.

environmental benefits position EGS as a key player in meeting California's energy goals, particularly in enhancing grid stability, within this decade.

Fervo recommends that the CEC recognize the strategic importance of EGS in energy planning and policy development, especially in integrating up-to-date assumptions including land-use impacts, cost declines, and resources available for import. Fervo is committed to contributing to California's clean energy future by developing and integrating EGS. We look forward to collaborating with the CEC and other stakeholders to ensure a smooth transition to a decarbonized and resilient energy grid.

Sincerely,

Sarah Harper
Policy and Regulatory Affairs Associate
Fervo Energy Company