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Fervo Energy Comment on the SB 100 Report Land Use Workshop

FERVO
ENERGY

15 February 2024

California Energy Commission
Energy Assessment Division
Docket Number 23-SB-100
715 P Street
Sacramento, CA 95814

Re: Senate Bill 100 Report Land Use Workshop Comments

Fervo Energy ("Fervo") appreciates the opportunity to comment on the California Energy Commission's ("Commission") February 1st, 2024 Senate Bill ("SB") 100 Report Land Use Workshop. The workshop provided a great overview of the Commission's consideration of the environmental and land use implications of meeting SB 100 targets. In response to the information presented at the workshop, Fervo would like to share how Enhanced Geothermal Systems (EGS) is expanding the viability of utility-scale geothermal energy production to regions previously deemed undevelopable while improving on conventional geothermal's already small low land use footprint and high energy density. The Commission's land use scenarios must be updated to adequately represent the advances in geothermal energy. Recent innovation and deployment of EGS resources position geothermal to provide a key role in meeting SB 100's goals, enhance California's energy security, resource diversity and carbon-free grid reliability.

I. ABOUT FERVO ENERGY

Fervo is a developer of utility-scale EGS projects with lease holdings across the west, including California. Fervo is actively developing projects to support the California grid, including the 400-megawatt Cape Station project in Beaver County, Utah. Cape Station is fully contracted with California load serving entities and will deliver its first phase of carbon-free electricity in 2026.

EGS opens access to a massive set of new subsurface heat resources and increases the capacity of projects to harness them. More capable generators and more abundant resources mean that EGS is rapidly increasing 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, the 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 Commission to integrate these new clean firm technologies and resources into the SB100 planning process to ensure a smooth and cost-effective pathway to a fully decarbonized grid.

II. INTRODUCTION

Fervo commends the Commission's dedicated focus on planning for a zero-emission energy future with respect to our treasured land resources. One of geothermal's great benefits is its energy density and limited land use footprint. These attributes mean that geothermal has the potential to provide gigawatts of clean, 24/7 power with limited impacts relative to other technologies. Advances in drilling have significantly cut costs and development timelines, while also increasing the resource potential per acre. Several assumptions made in the February 1, 2024 SB100 Report Land Use Workshop are based on outdated practices and undervalue the improvements in energy production per acre made possible through innovation in EGS. Fervo would like to work with the commission to update these assumptions in order to support SB100 goals of planning for a fully decarbonized grid by 2045.

III. DISCUSSION

Fervo seeks to collaborate with the Commission to incorporate technological advances in geothermal into the electricity system modeling in support of achieving SB100. Namely, Fervo is concerned that the lag in incorporating EGS advances into CEC resource potential metrics will result in inadequate resource planning given the major developments in the geothermal industry due to EGS. To reflect the innovation and availability of next-generation geothermal technologies, the Commission should update the land-use screens, particularly the Capacity Density Metrics, to reflect the greatly expanded resource potential of geothermal energy today.

1. EGS is being deployed at scale today and demonstrating learning curve cost improvements and access to huge new potential resources.

One of the important innovations of EGS is the use of replicable well designs concentrated in specific resource basins. This modular approach reduces resource risk and allows EGS to unlock cost and speed improvements previously unavailable to conventional geothermal development. Geothermal drilling costs have often represented more than half of total project costs, so drilling performance improvement is critical to achieving durable cost reductions. Between our first well in 2022 and current drilling campaign at Cape Station, Fervo reduced drilling time by 70%. The learning curves evidenced by Fervo's actual field development (see Figure 1) demonstrate that EGS benefits from an aggressive learning curve that is unique from traditional hydrothermal resources and requires an updated and separate approach to measuring resource potential.

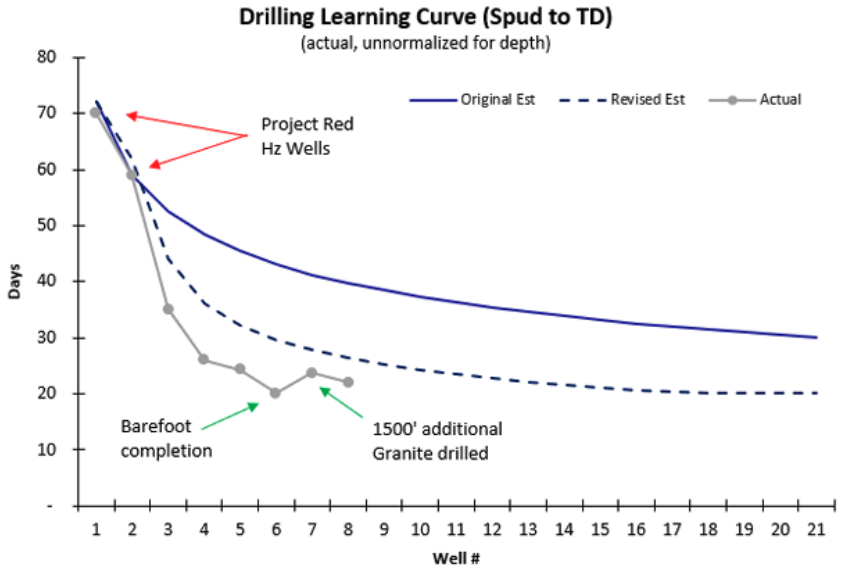

Figure 1: Fervo EGS Drilling Learning Curve (spud to actual TD) showing planning 18% learning curve and realized 35% learning curve across all EGS projects.
Source: El-Sadi et al. 2024

The learning curves experienced at Fervo's projects exceed the projections set by the Department of Energy's (DOE) Enhanced Geothermal Shot Initiative which anticipates EGS to become a crucial component of the United States' clean energy portfolio. While the DOE supports a wide range of research and development in EGS, the industry is already demonstrating progress ahead of schedule and indicates the need for more aggressive deployment forecasts which should be included in the SB 100 resource potential calculations. Led by reduced drilling times, Fervo foresees transformative performance

improvements across the development process with wide ranging implications for the geothermal energy industry (see Figure 2).

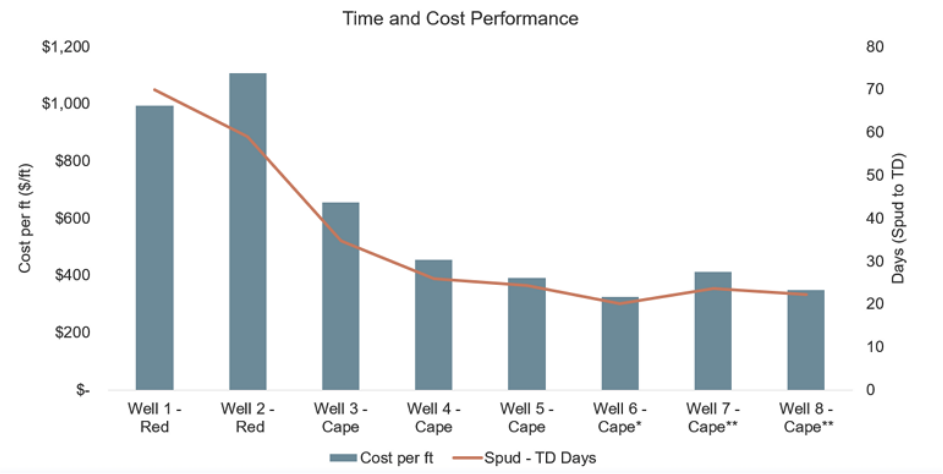

Figure 2: Fervo horizontal well cost per ft and spud to TD trends
Source: El-Sadi et al. 2024

The cost declines experienced through project deployment, and the massive new resources available for EGS development has put California on the cusp of a geothermal boom. The SB100 land use report presented in the February 1, 2024 workshop demonstrates outdated assumptions about geothermal energy resource potential relative to its land use footprint. For example, the Capacity Density Metrics feeding into the CEC's "Scale of Potential Acreage Requirements for Clean Electricity Resources" chart on slide 4 presents geothermal energy as having a Capacity Density Metric of 9 acres/MW. Based on our projects, including our 400MW project Cape Station serving California, this number is grossly high. Fervo's achievements in drilling cost and commensurate improvements in energy production per well further indicate the need to reconsider EGS as a unique resource. Thus, omitting EGS advances in modeling has resulted in cascading impacts that will mislead land planning efforts.

2. EGS is being deployed at scale today in regions previously considered inaccessible for utility-scale geothermal electricity generation maintaining a low land use footprint.

Geothermal energy is a carbon-free resource with the lowest land use requirements of any renewable energy source (see Figure 3). Modern EGS uses an efficient "binary cycle" process to convert heat to electricity, emits no carbon or other pollutants and has extremely low water use requirements. EGS technology taps into vast underground heat sources and maintains a low profile at the surface, enabling gigawatts of electricity to be generated with little disruption to land. Paired with major advances in the subsurface, geothermal energy potential per acre has become vastly more energy dense than was previously believed possible.

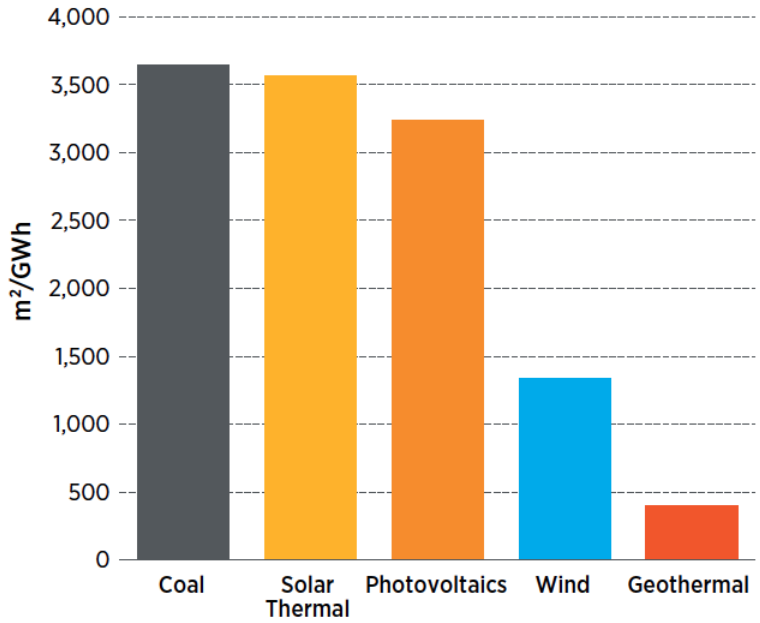

Figure 3: Land footprint by GWh_e for various electricity-generation technologies
Source: Kagel et al. 2007

Zero carbon, 24/7, dispatchable resources are key to unlocking a fully decarbonized electricity sector and geothermal stands to play a major role. As outlined in the Department of Energy's GeoVision Study and EarthShot Initiative, breakthroughs in EGS technologies could unlock over 100 GW of clean firm power in the United States.[1] The EGS revolution is underway, expanding the commercial viability for geothermal energy to meet energy needs and it is key that land use planning efforts adequately represent these advances.

Such advances have transformative implications when looking at the resource potential across California and the west. Accepted scientific literature suggests that commercial electricity generation is generally economic from geothermal resources at temperatures above 150°C which are widely—but not uniformly—distributed underground and become more common with increasing depth.[2] Geothermal resource temperatures at a depth of 7 km (about 4 miles) are accessible with existing drilling technology and Fervo has already proven the ability to drill deeper in a timely and cost-effective manner (see Figure 4 and 5).

[1] Augustine, C., S. Fisher, J. Ho, I. Warren, and E. Witter. 2022. *Enhanced Geothermal Shot Analysis for the Geothermal Technologies Office.* Technical report NREL/TP-5700-84822. National Renewable Energy Laboratory.

[2] DOE. 2019. *GeoVision: Harnessing the Heat Beneath our Feet. T*echnical report. U.S. Department of Energy (DOE).

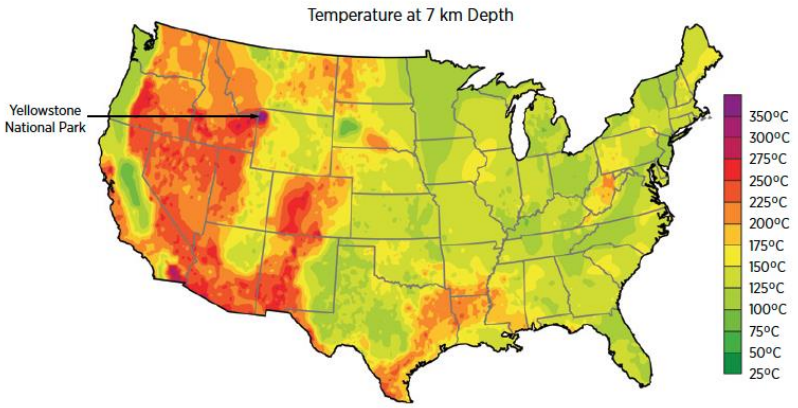

Figure 4: Temperatures throughout the contiguous United States at a depth of 7km (about 4 miles)
Source: Blackwell et al. 2011

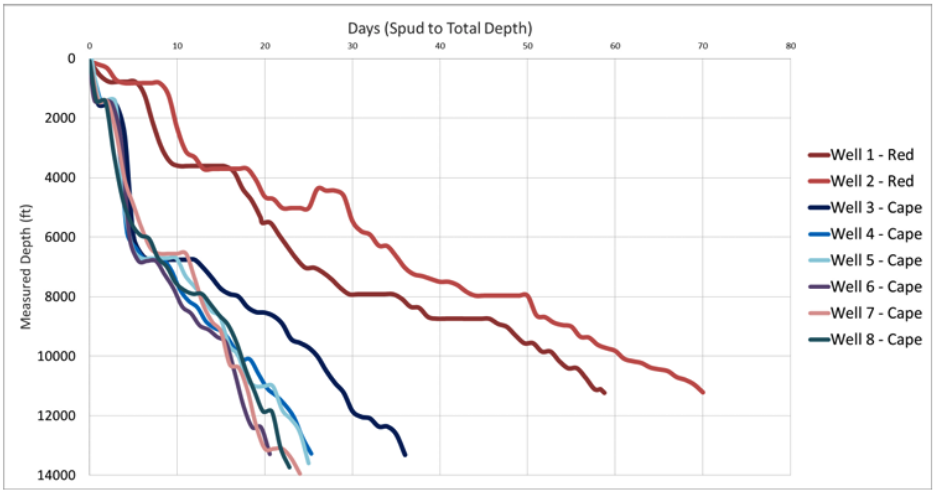

Figure 5: Spud to Total Depth (TD_ results for Fervo EGS Wells
Source: El-Sadi et al. 2024

The ability to access higher flow rates and heat capture from previously inaccessible subsurface thermal resources introduces a new paradigm in geothermal resource potential. Historically, geothermal resources have been limited to only the most favorable geologic hot spots. The challenge of tapping these specific subsurface reservoirs led to a high rate of "dry holes" and poses a challenge commercial geothermal development. Fervo's EGS technology overcomes these barriers by significantly improving the repeatability, predictability, and range of geothermal projects across the United States and in California.

IV. CONCLUSION

Despite recent progress, EGS is still considered an early-stage technology under many California modeling paradigms. However, unlike many nascent technologies, EGS does not rely on the invention of a new and unproven widget. Instead, EGS applies a suite of technologies already proven and perfected in other subsurface applications. This approach dramatically reduces technology risk, and as shown by

Fervo's successfully operating commercial pilot, means that EGS has achieved a Technology Readiness Level 8.[3] EGS is ready to provide clean-firm capacity at scale with zero carbon emissions and an extremely low land use footprint. With no significant fundamental technical risks remaining, the focus must now be on consistency, replicability, and cost reduction which are all significantly bolstered by accurate modeling and procurement.

Fervo Energy recognizes that the EGS field is rapidly developing and will take time to fully integrate into California resource planning. However, as currently proposed, the Commission's land use assumptions feeding into SB100 land grossly undervalue the resource potential of geothermal energy as a whole as well as the resource potential per acre which will lead to misinformed land use planning. We appreciate the Commission's prior leadership in supporting and incorporating new clean energy technologies, and we are excited to continue that work with next-generation geothermal. We welcome open communication and coordination on these important issues and look forward to working together with the Commission to achieve an affordable, reliable, and carbon-free future.

Sarah Harper
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Fervo Energy Company

[3] The Department of Energy's Technology Readiness Level Scale defines TRL 8 as an "actual system completed and qualified through test and demonstration." Fervo's commercial scale pilot, Project Red, is online, producing energy and satisfies those real-world conditions at scale. https://www.directives.doe.gov/directives-documents/400-series/0413.3-EGuide-04/@@images/file