Hydraulically Fractured Horizontal Wells and Other Oilfield Technologies are about to Revolutionize the Production of Electricity from Geothermal Resources

Greg Leveille
September 23, 2024

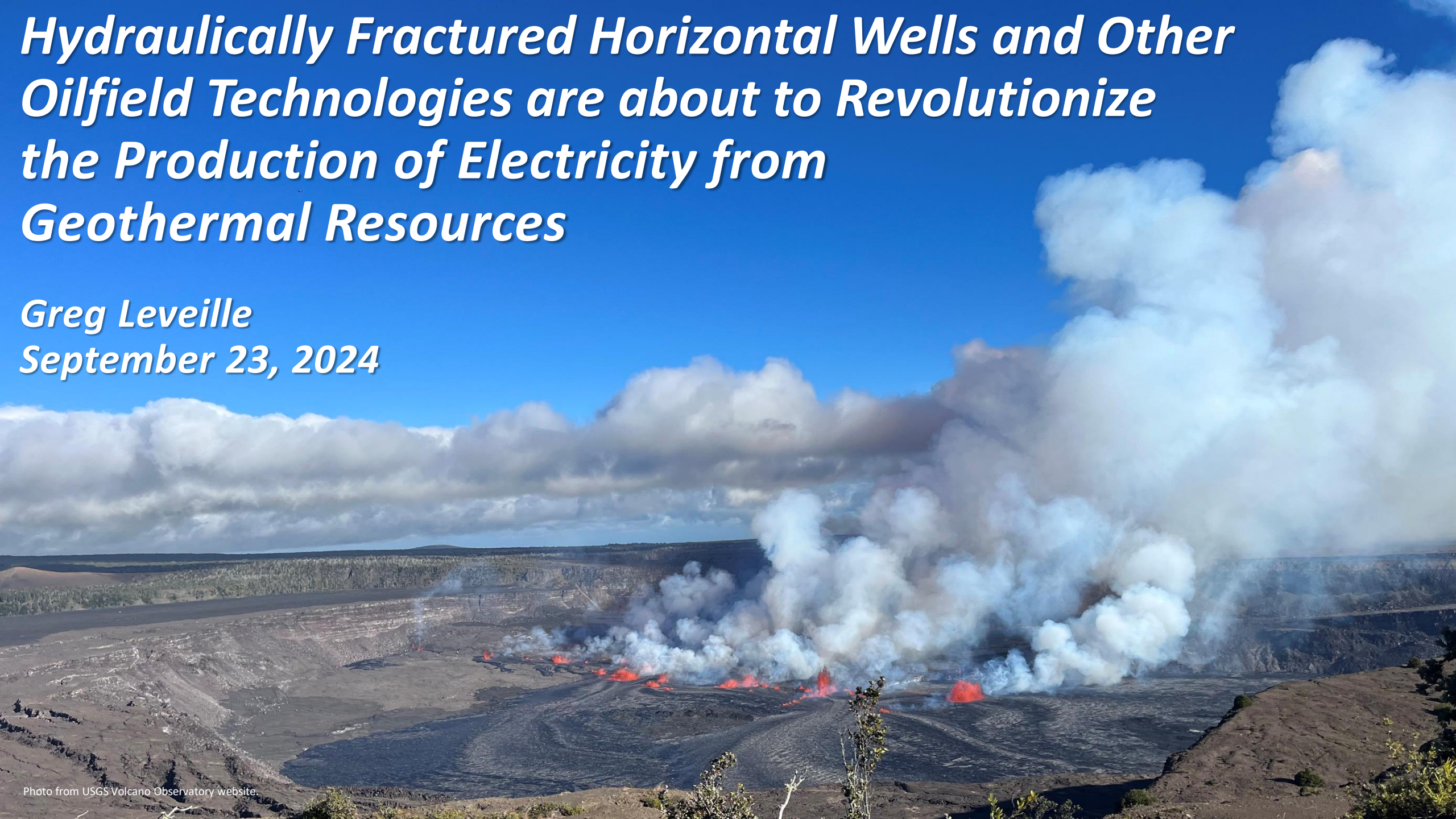
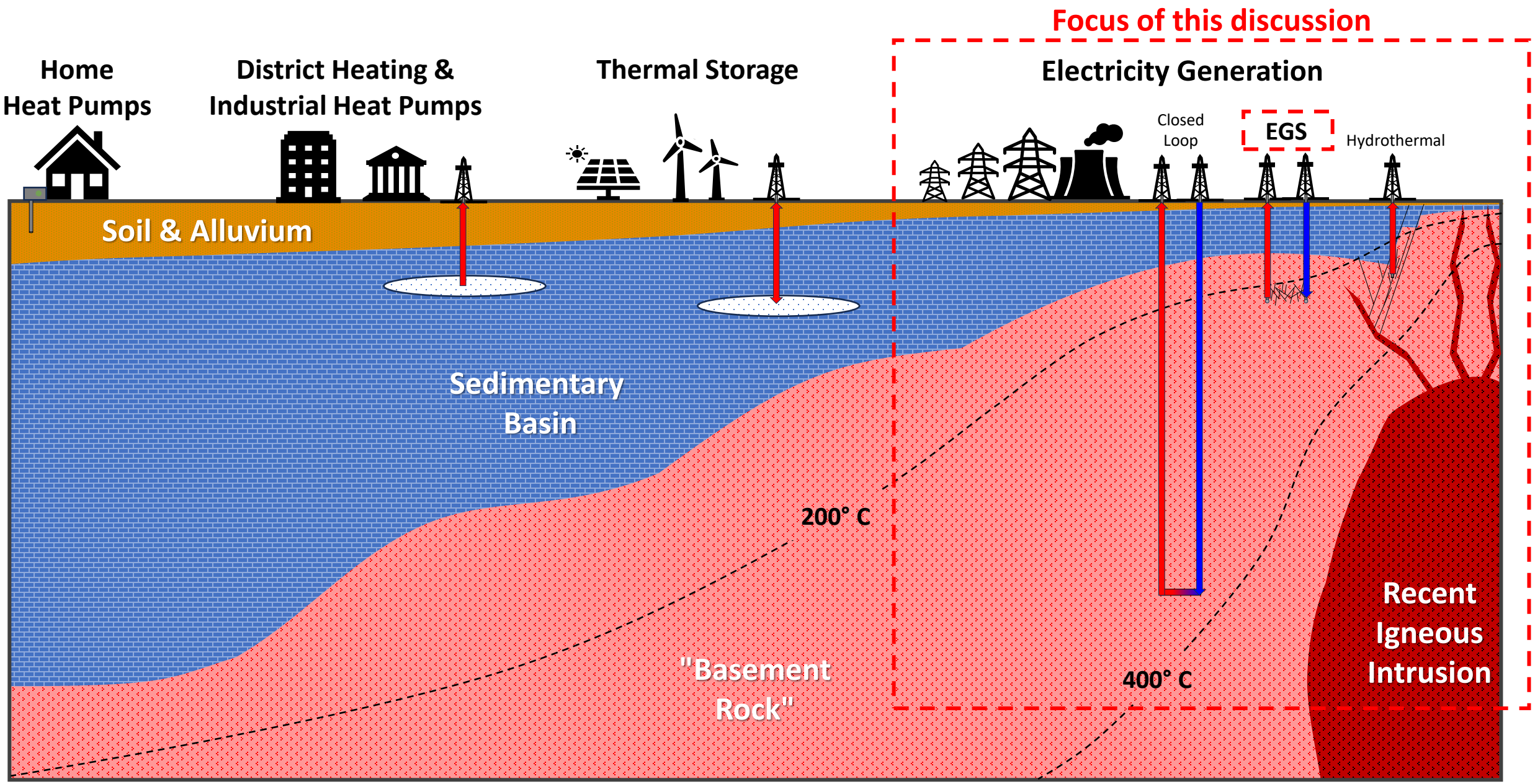


Photo from USGS Volcano Observatory website.

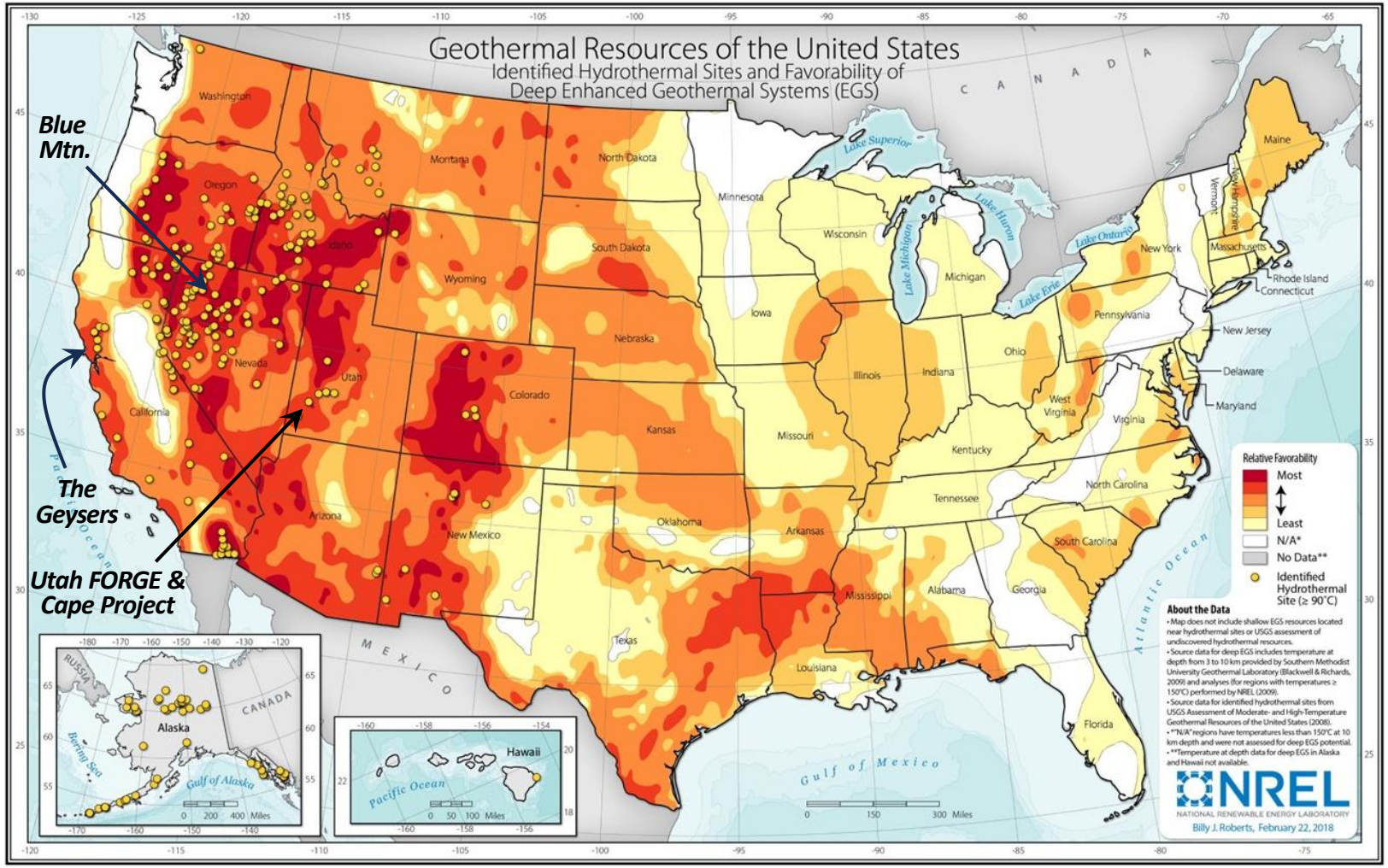
There are many ways to extract energy from geothermal resources



Cross section views; not to scale; depiction of the systems used to extract geothermal resources are greatly simplified; EGS = Enhanced Geothermal Systems.

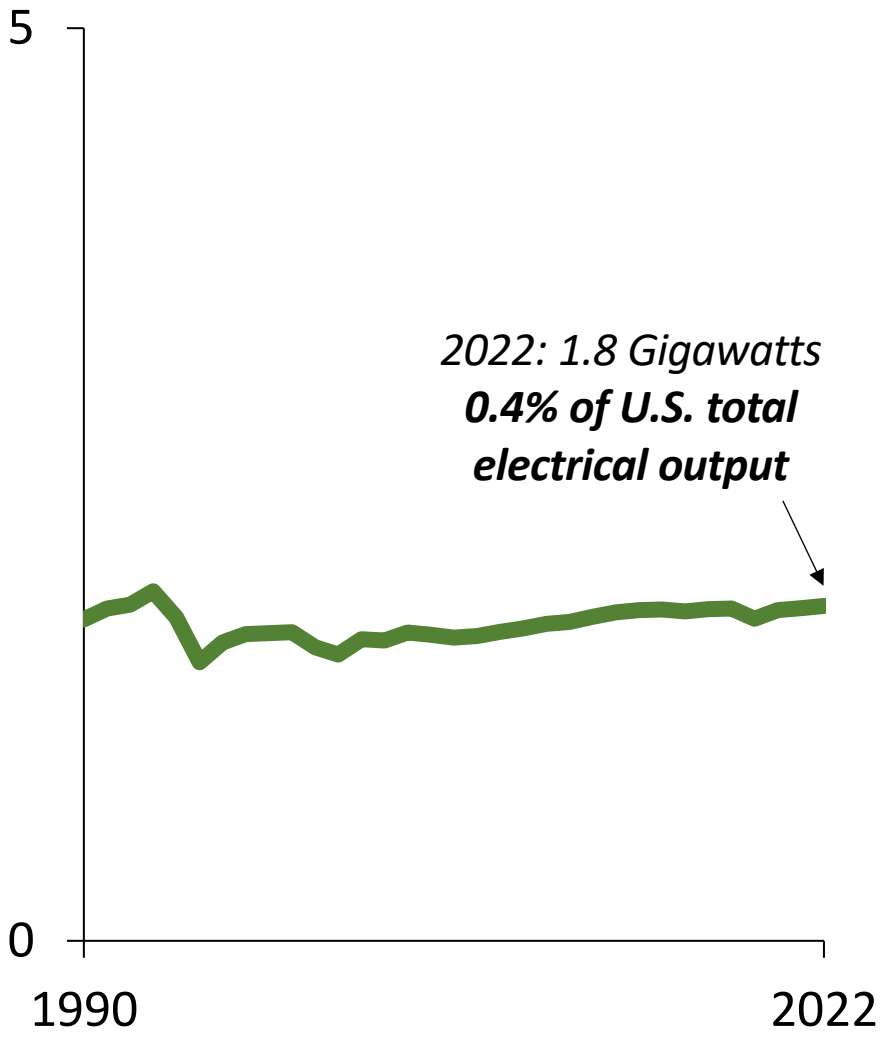
Electricity from geothermal: Enormous potential, disappointing results to date

Geothermal resources have the potential to supply nearly inexhaustible amounts of electricity



Map taken from U.S. NREL website

But U.S. electricity output from geothermal is negligible



Source: U.S. EIA ; plot shows annual average instantaneous electricity output

Two of three high-level "Critical Drivers" of geothermal power economics have recently changed substantially for the better

Focus of this talk

Subsurface
(Extracting heat cost effectively)

- D&C costs down
- Heat output up
- Risks reduced

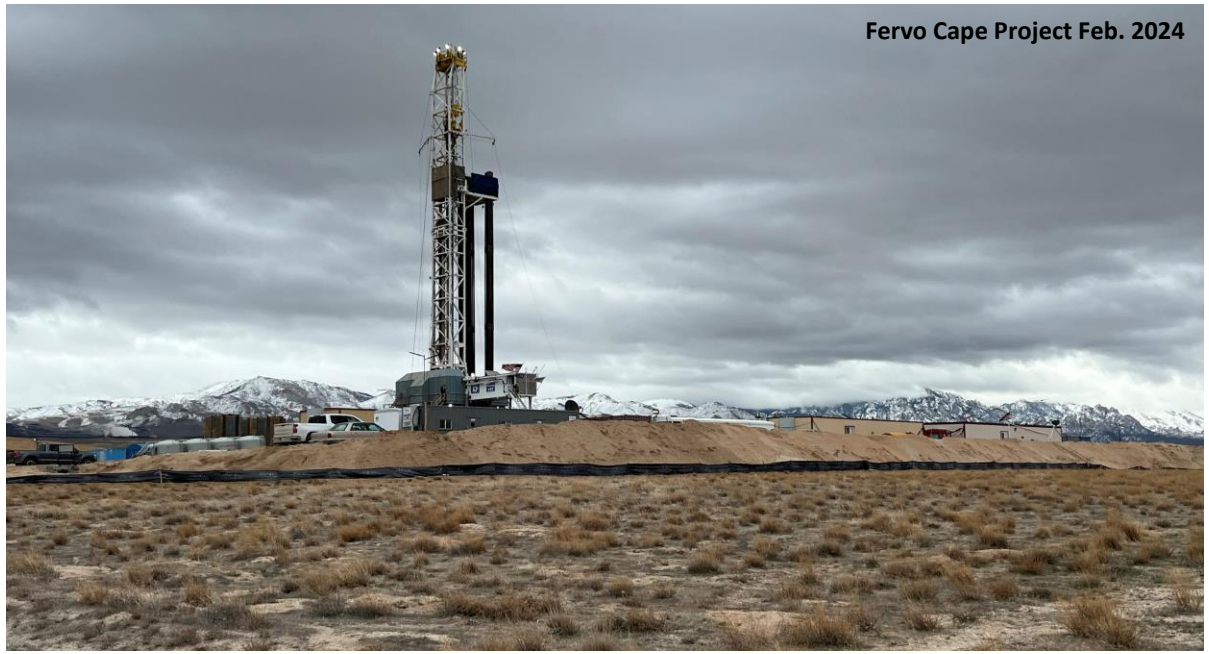
Facilities[1]
(Converting heat to power)

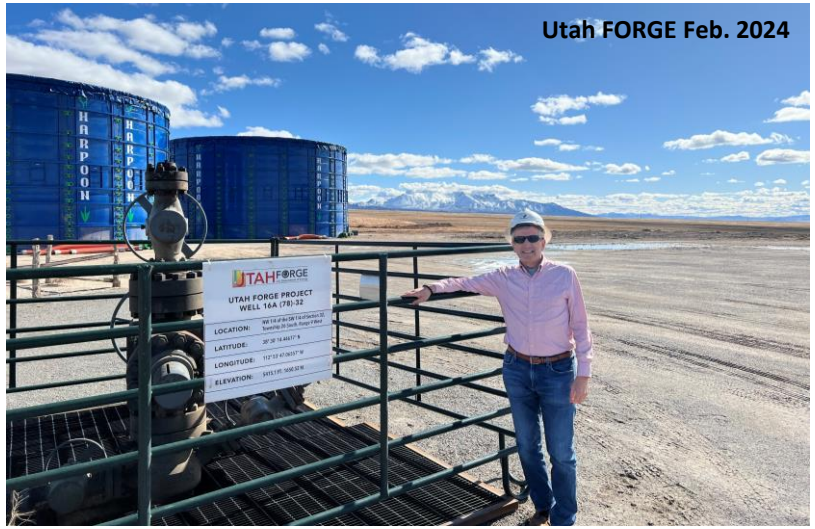
Commercial
(Electricity pricing & project financing)

- Premium pricing
- Government support
- Lower cost of capital

[1] Potential exists for significant cost reductions for larger scale projects

Oil & Gas unconventional reservoir technologies and workflows are transforming the cost effectiveness of extracting heat from the Earth's crust

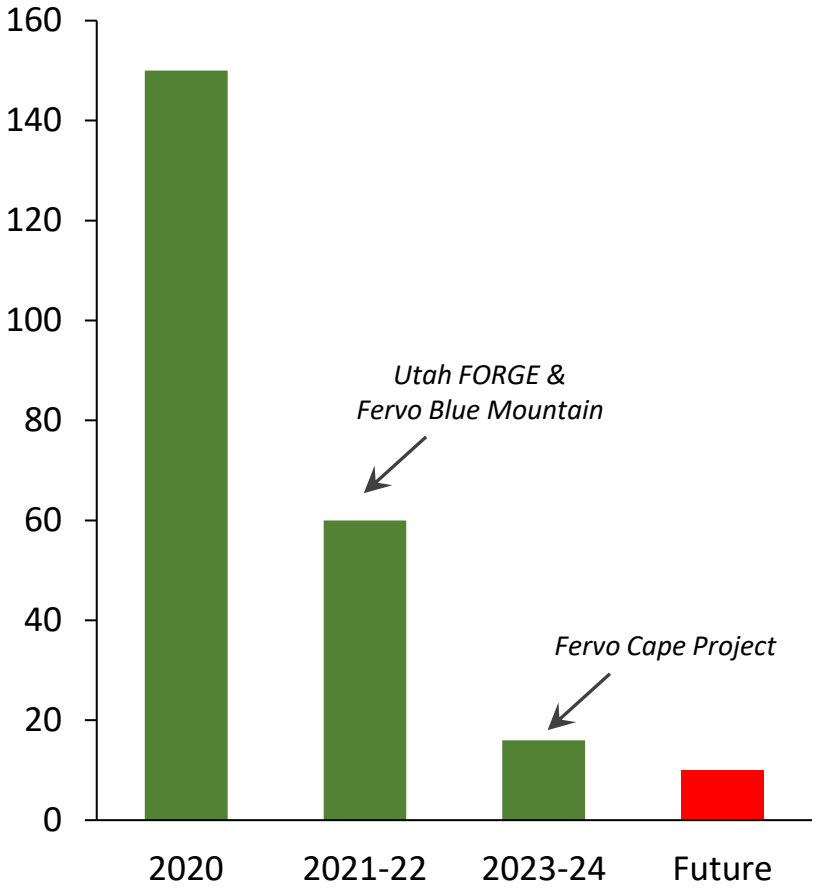




Subsurface-related improvements have been dramatic; Likely more to come!

Dramatic drilling performance improvements

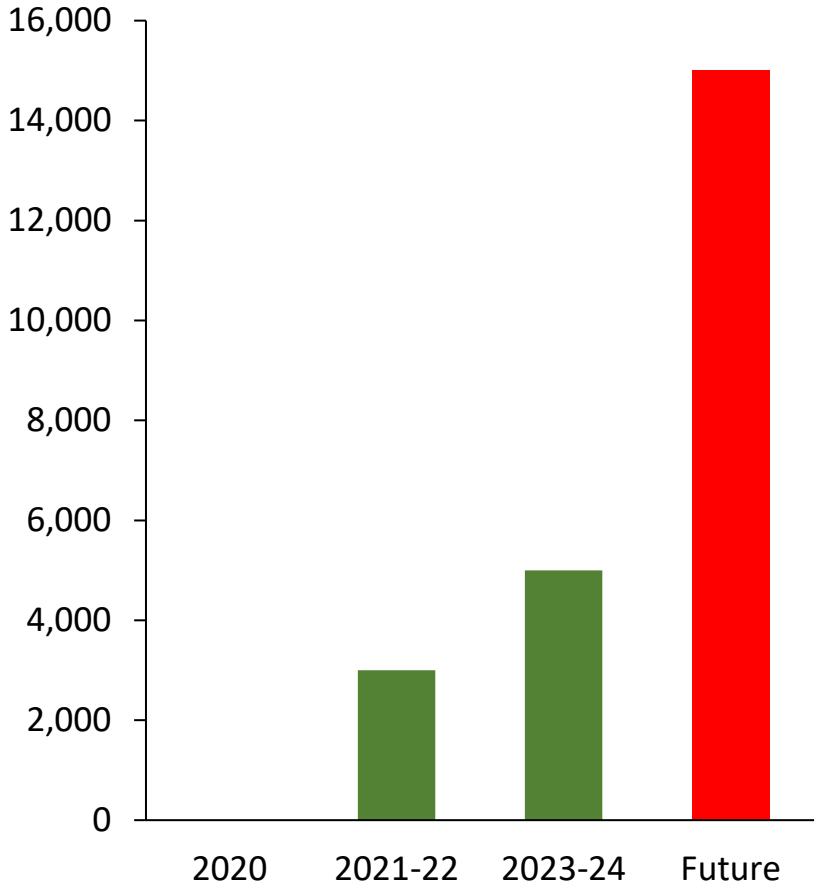
Drilling days to 12,000' MD



Sources: El-Sadi et al, 2024, Review Of Drilling Performance In A Horizontal EGS Development; Winkler and Swearingen, 2021, Summary of Drilling Activities, Well 16A(78)-32 (Utah FORGE)

Ability to D&C horizontal laterals in basement rocks

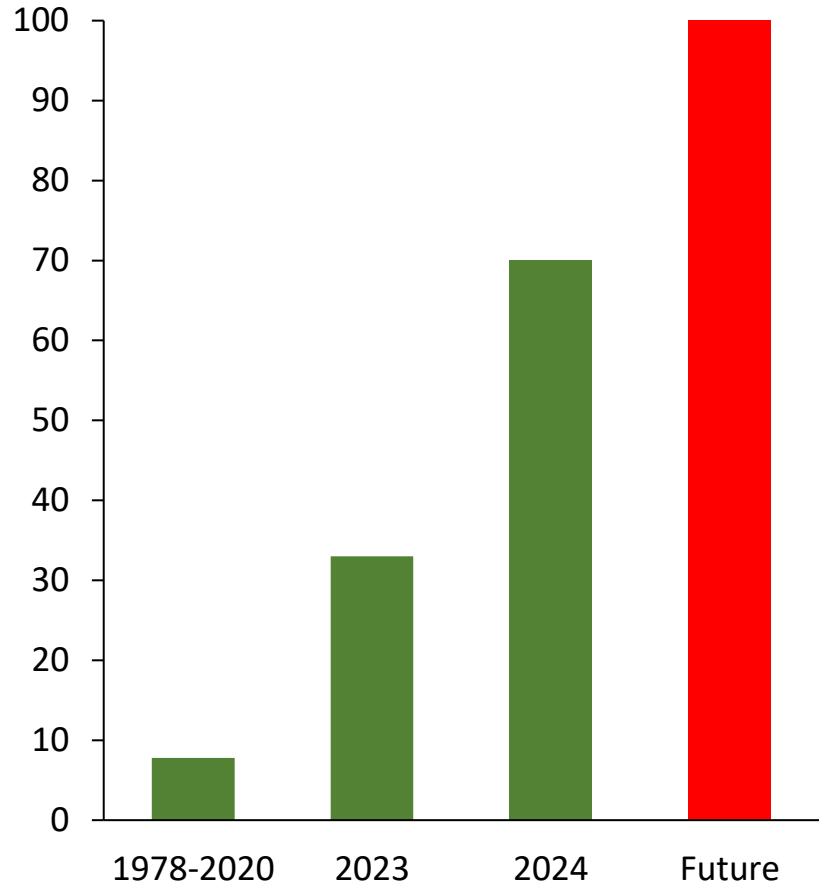
Lateral length (feet)



Note: The first fully horizontal EGS wells drilled were those drilled by Fervo at their Blue Mountain project in 2022. D&C = drill and complete

Ability to achieve high flow rates and good conformance

Peak production flow rate (MBFPD)



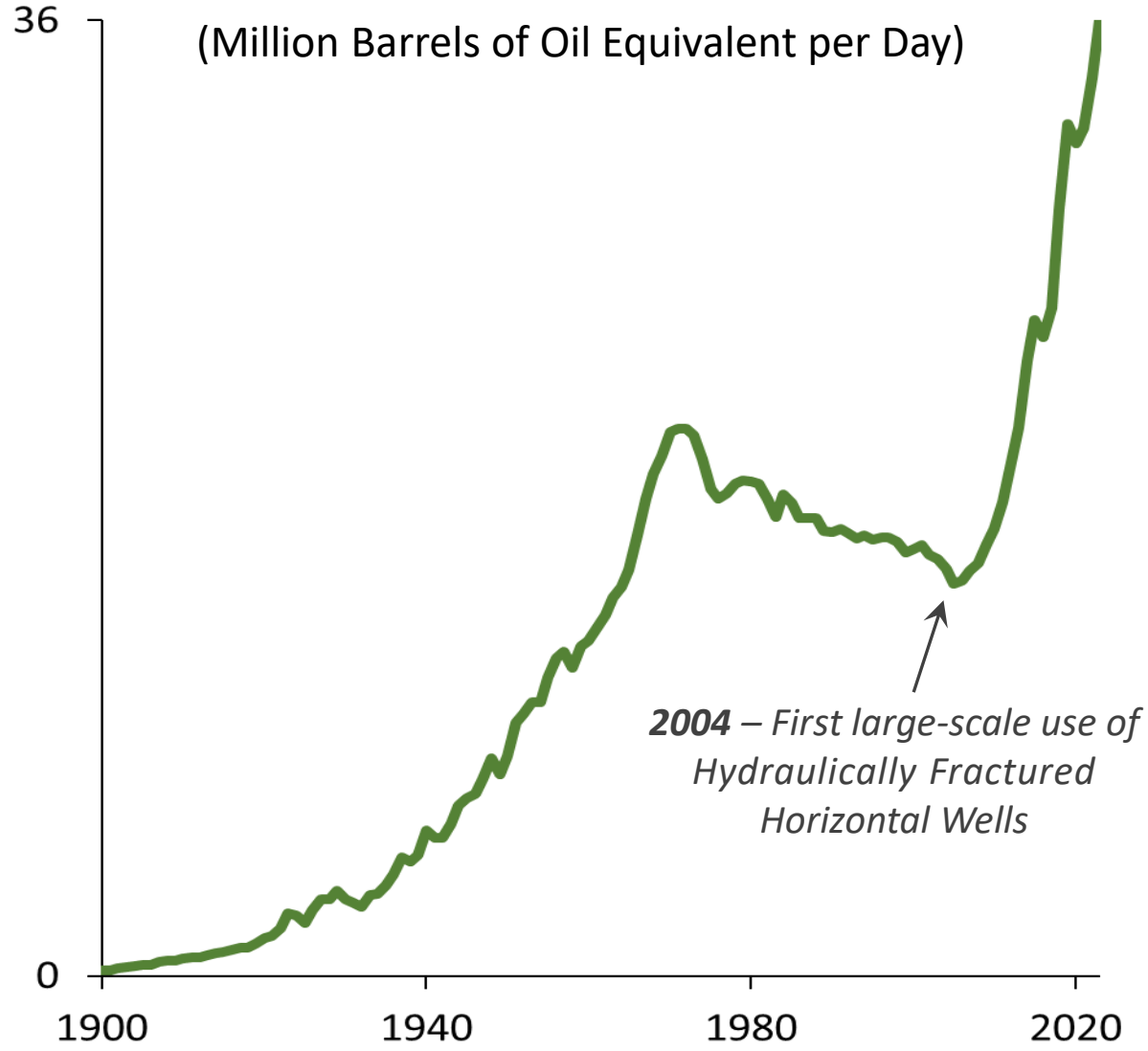
Note: 1978 – 2020 data from 11 projects; average peak flow rate shown (7,800 bfpd); range was from 2,700 to 16,300; 2023 Fervo's Blue Mtn. project, 2024 FervoCape

What makes for an "Ideal Geothermal Prospect" is different when using hydraulically fractured horizontal wells

Hydrothermal systems	Enhanced Geothermal Systems (EGS)	
Vertical wells	Vertical wells	Horizontal wells
• High subsurface temperature	• High subsurface temperature	• High subsurface temperature
• Pervasively fractured rocks	• Pervasively fractured rocks	
• Overpressured, fluid-filled fractures		***"Minimally fractured rocks" preferable to reduce the likelihood of thermal breakthrough, excessive leakoff, and induced seismicity***
• Pressure recharge mechanism		
EXCEEDINGLY RARE	***EXCEEDINGLY DISAPPOINTING***	***RIGHT TOOL FOR THE JOB***
Example: The Geysers, California	Example: Most EGS projects 1970-2023	Examples: Cape Project & Utah FORGE

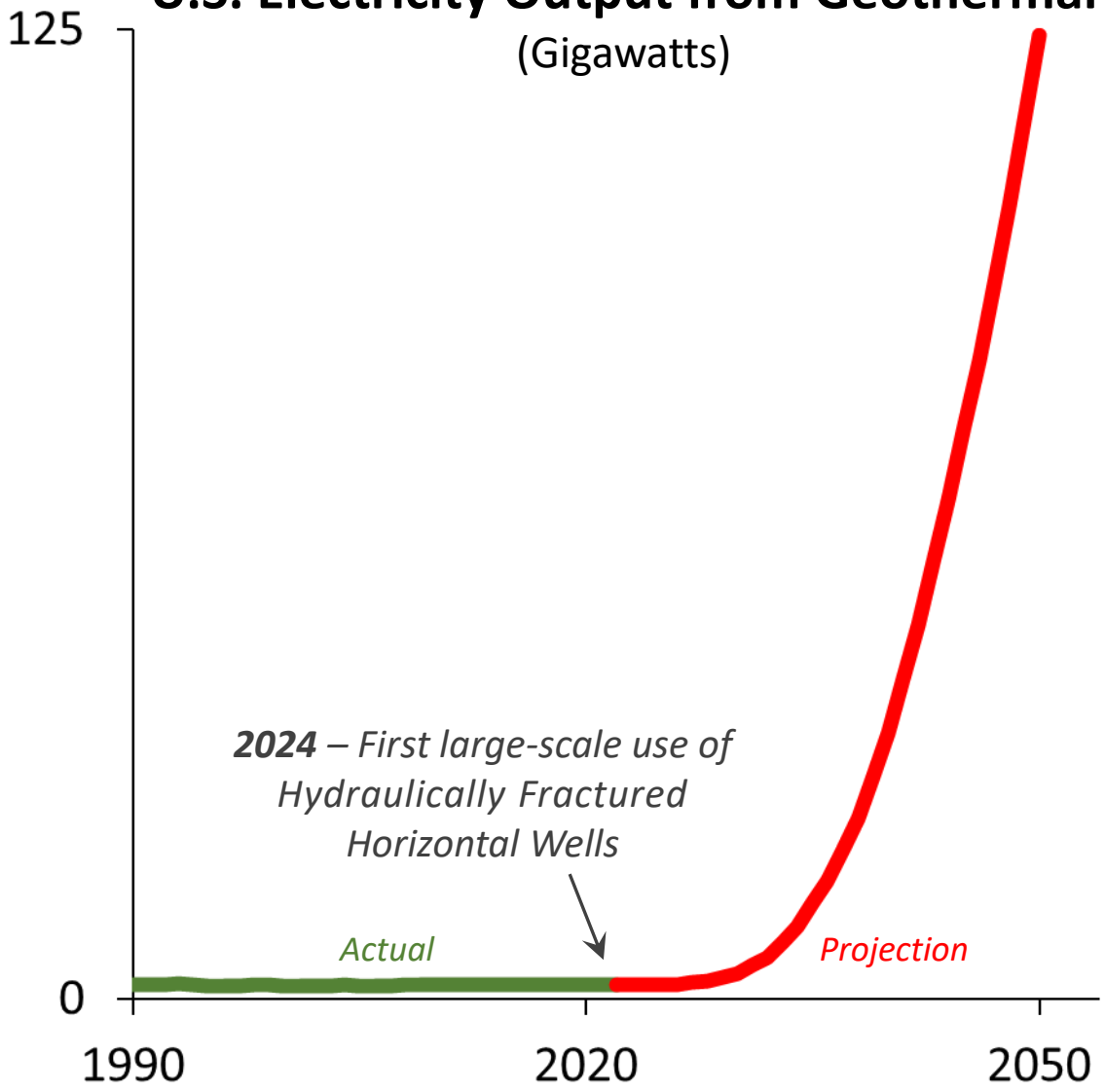
Could oilfield technologies enable a geothermal power breakthrough like that achieved in unconventional oil & gas reservoirs?

U.S. Oil & Natural Gas Production



Sources: U.S. EIA, Energy Insights, and BP websites

U.S. Electricity Output from Geothermal



Sources: U.S. EIA for 1990 to 2022; 2022 average output = 1.8 GW (0.4% of U.S. total); Author projection from 2023 to 2050

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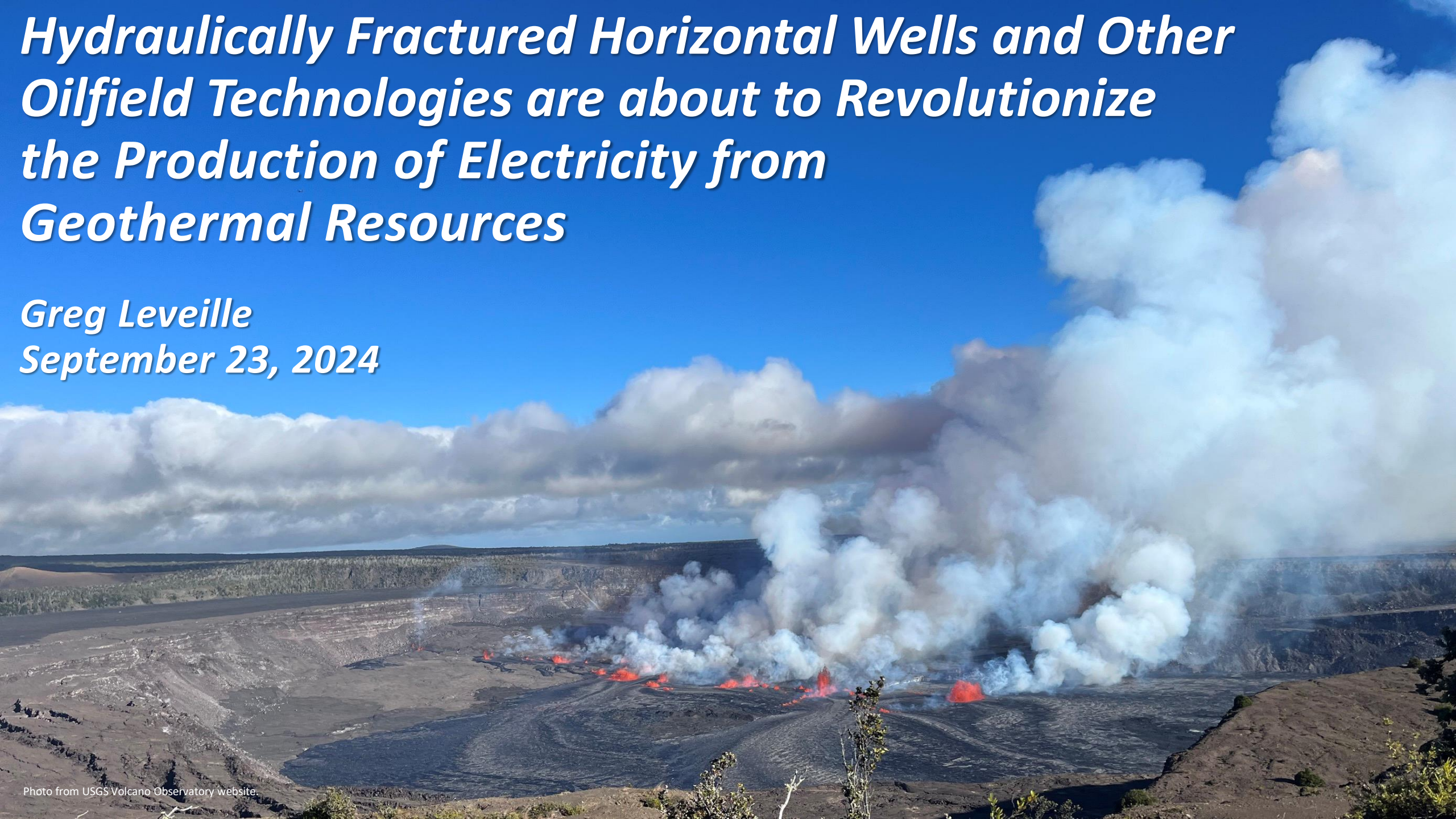

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