Enhanced Geothermal Systems: Recent and Future Technological Innovations

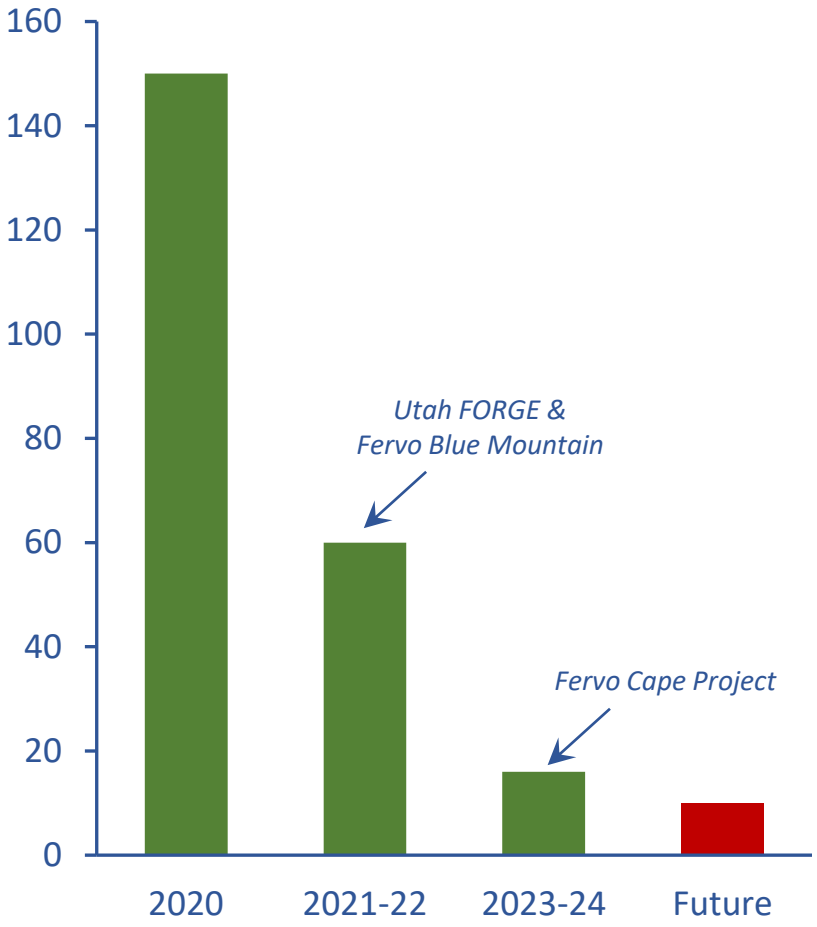
Greg Leveille

November 20, 2024

Technological innovations have recently delivered game changing results

Spectacular drilling performance improvements

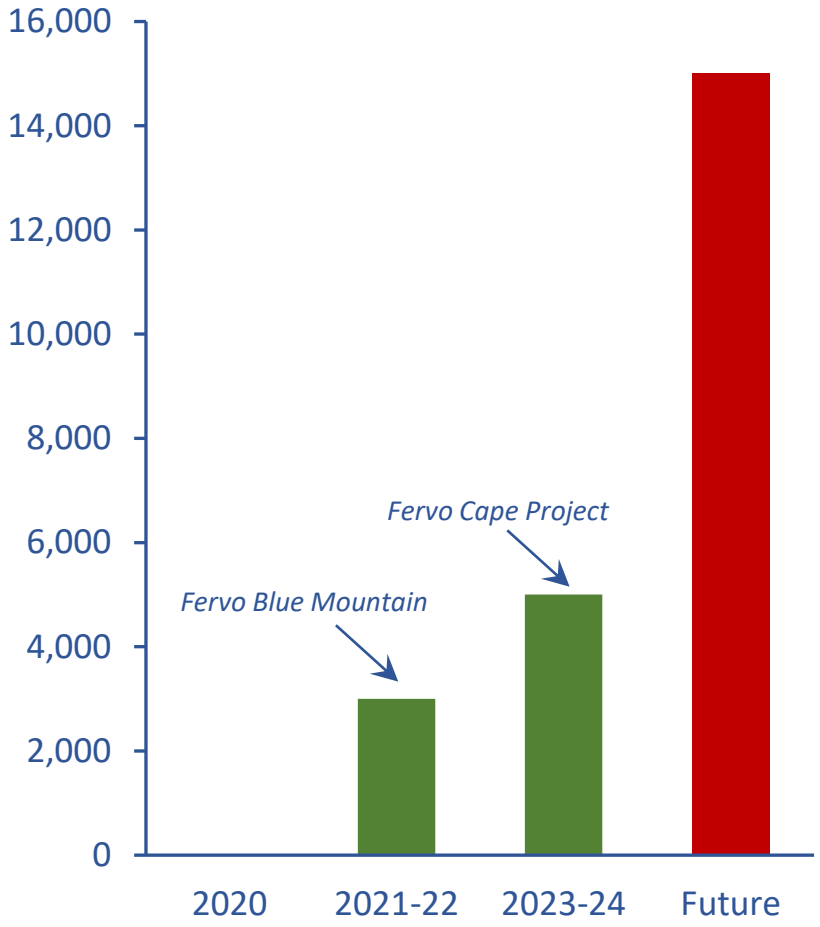
Drilling days to 12,000’ MD



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

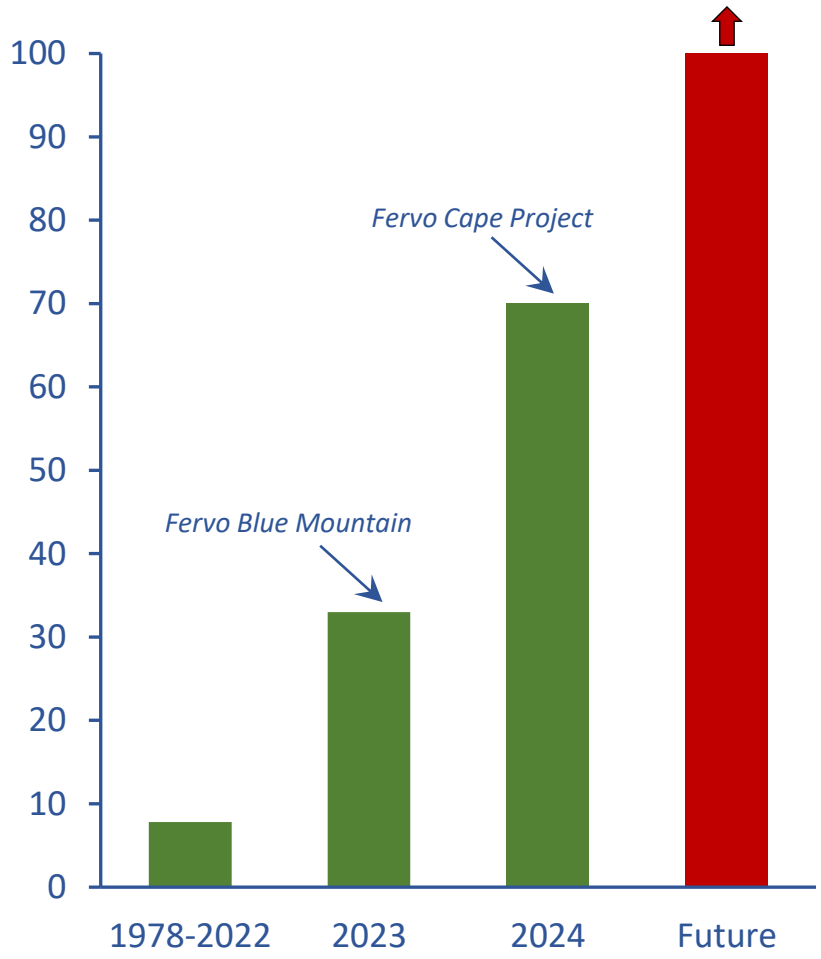
Lateral length (feet)



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

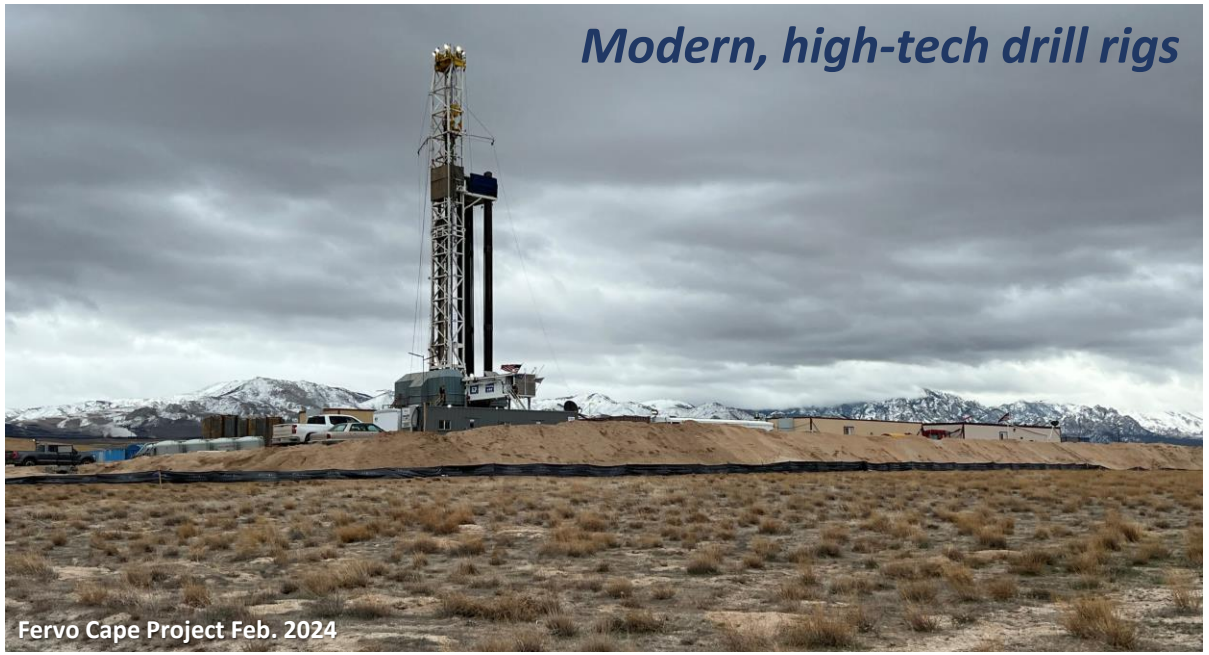
Near order-of-magnitude increase in per well production

Peak production flow rate (MBFPD)

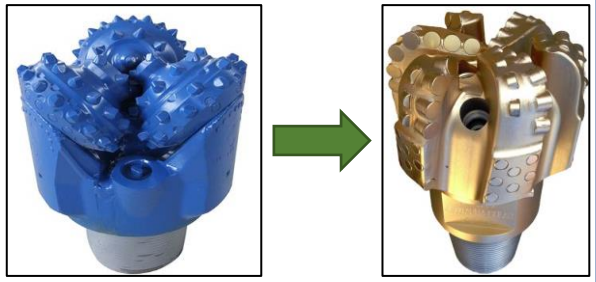


Note: 1978 – 2020 data from 11 projects; average peak flow rate shown (7,800 bfpd); range was from 2,700 to 16,300

Technology transfer from the oil & gas industry is transforming EGS economics



Drill bit design



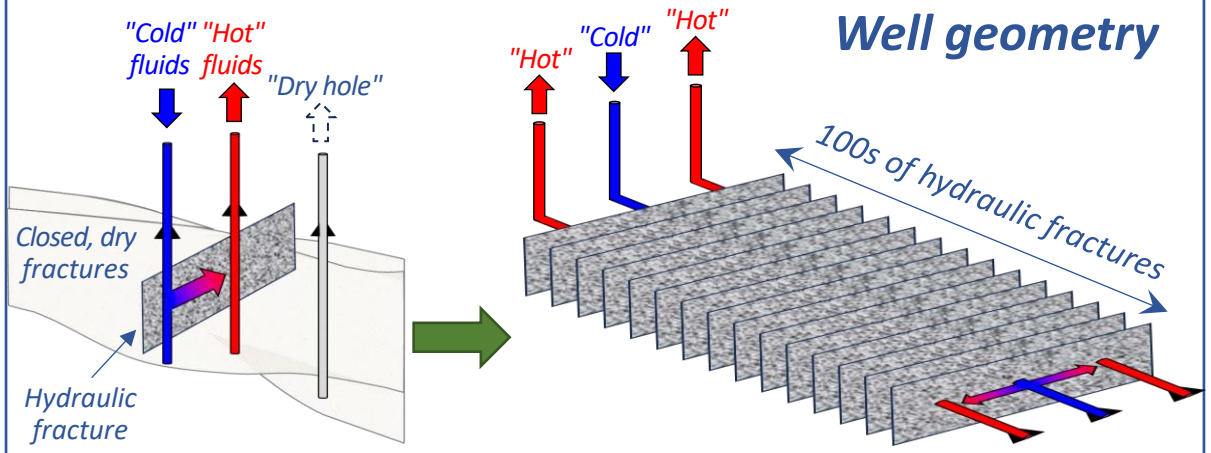
Roller Cone → PDC

Physics-based drilling

Fred Dupriest
& Sam Noynaert

Texas A&M University

Well geometry

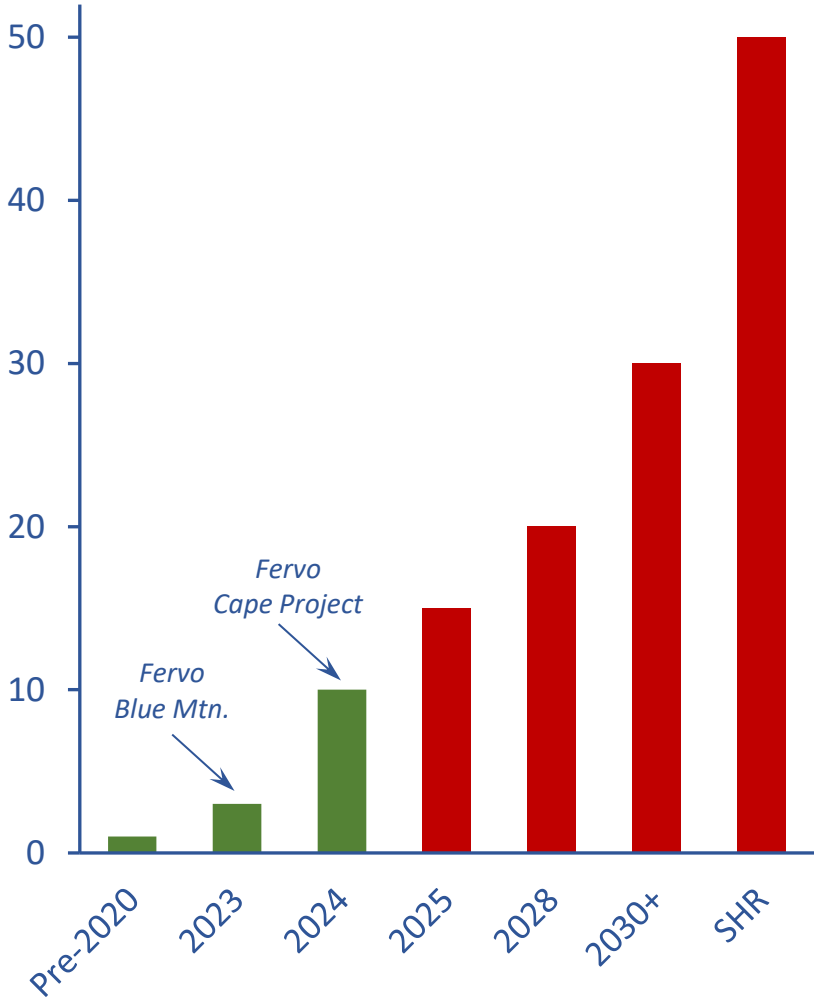


Vertical Wells → Horizontal Wells

Oblique views; not to scale

Technological innovations have vastly improved EGS project outcomes

Per well power output (MW)



SHR = Super hot rocks

Science & engineering efforts underway to further improve results

Higher Flow Rates

- Larger casing = >rate
- > Fracture conductivity
- Blue Mtn. 25M bfpd
- Cape design 70M bfpd

> Thermal Output

> Fracture Surface Area

- Longer laterals
- Wider well spacing
- LL: 3M → 5M → 15M ft.
- WS: 300’ → 600’ → __

>Thermal Longevity

One Plant / Deeper Layers

- Synergy with Super Hot Rocks progress
- Reuse as much of plant as possible after initial wells die

Lower Plant Cost

Super Hot Rocks

- Blue Mtn. ≈ 375° F
- Cape 400° to 435° F
- SHR target 705° F[1]
- ≈ 1 MW per 25° F[2]

> Thermal Output

Improved Conformance

- Well placement
- Completion design
- Operating practices
- Remediation options

>Thermal Longevity

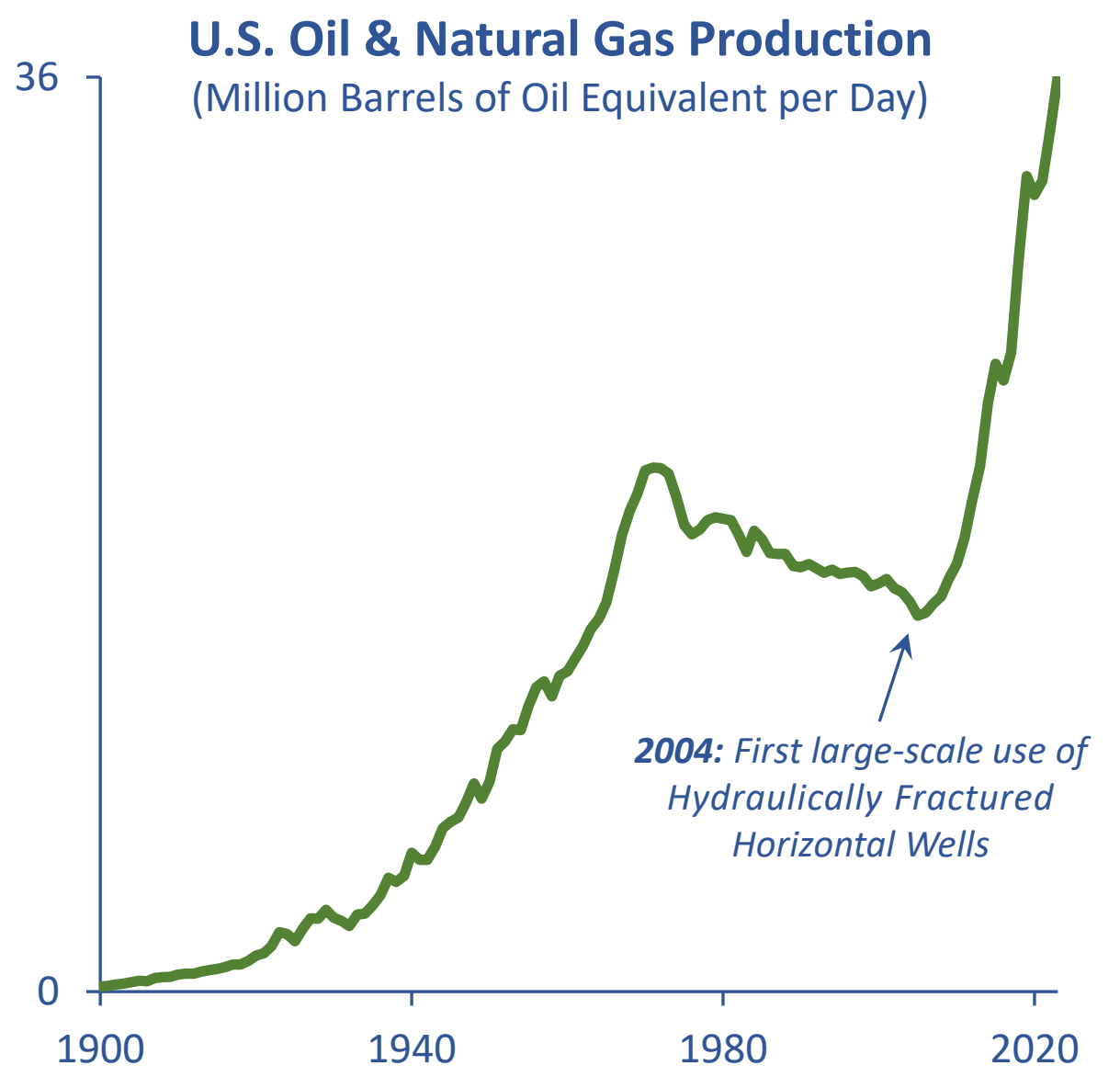
Scaling Management

- Robust scaling characterization and treating programs
- Same for corrosion

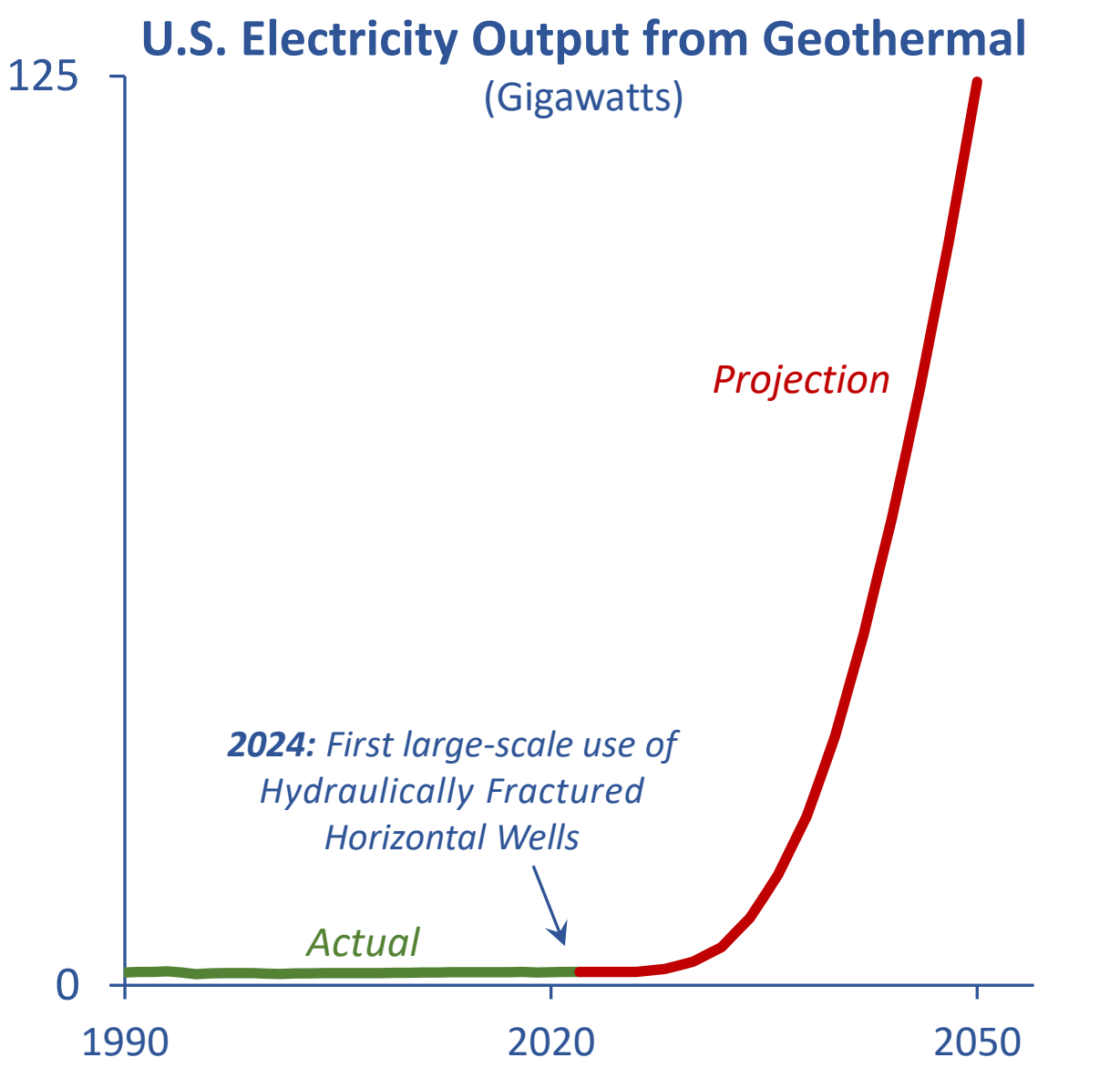
Plant & OPEX Cost

Not an exhaustive list; [1] 374° C; [2] at 50,000 bfpd flow rate

Oil & gas technologies are poised to enable a geothermal power breakthrough like that achieved in unconventional O&G reservoirs



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



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