cleanecon

C3 SOLUTIONS

WAYPOINT STRATEGY GROUP

frontiers
build what is missing

POLICY PAPER

Geothermal Appraisal Risk Program

Accelerating EGS Deployment Through Targeted De-Risking Across U.S. Basins



May 2026

Prepared by CleanEcon, C3 Solutions, and Waypoint Strategy Group

Table of Contents

01	Executive Summary	2
02	The Case for Urgency	4
03	Strategic Rationale	5
04	Proposed Solution	7
05	Relationship to Current Policy	9
06	Anticipated Impact and Value	10
07	Next Steps	11
A	APPENDIX Implementation Stages	13
B	APPENDIX Key Appraisal Data Parameters	14

Image credits. Cover, Next Steps and Appendices illustrations: CleanEcon. Map (p. 5): NREL, *Geothermal Resources of the United States*, Billy J. Roberts, 2018. Photographs (pp. 4 and 7): see captions.

01 Executive Summary

Enhanced Geothermal Systems (EGS) technologies have crossed a critical threshold. Development costs have dropped nearly 50% in two years, drilling rates have increased 500%, and the U.S. resource base exceeds 5,000 GW across all 50 states. The question is no longer whether EGS works, but where and at what cost it can be deployed commercially. Answering these questions requires appraisal drilling, and appraisal risk is the industry's binding constraint.

DEVELOPMENT COSTS

−50%

Development costs have dropped nearly 50% in two years

DRILLING RATES

+500%

Drilling rates have increased 500%

U.S. RESOURCE BASE

5,000+ GW

The U.S. resource base exceeds 5,000 GW across all 50 states

Appraisal risk is distinct from the binary "dry hole" risk of conventional geothermal. It is a spectrum of viability shaped by subsurface conditions, development approach, and project economics, including cost of capital, expected power purchase agreement terms, and financing structures. It is reducible with data that characterizes parameters like permeability, temperature, and flow rate, which vary by geology, meaning the industry needs appraisal across diverse settings to unlock institutional capital at scale. Federal appraisal investment has a track record here. DOE's Geothermal Resource Exploration and Definition (GRED) program (1982–2012) characterized subsurface conditions across the western U.S., enabling private developers to finance projects with confidence, and is credited with identifying much of the nation's current geothermal capacity.

Two recent developments have strengthened the case and sharpened the opportunity:

- **DOE's Office of Geothermal has launched DE-FOA-0003472**, with $71.5 million for resource exploration, characterization, and confirmation drilling (Topic Area 6). This is a direct validation of the need. But at $4–8 million per award and 8–18 anticipated projects, the solicitation addresses individual site confirmation rather than the systematic, multi-basin appraisal campaign needed to shift market-wide confidence. There may be an opportunity to advance the work through future releases of the other Topic Areas in that solicitation, but availability of sufficient funds is uncertain, and alternative program designs might provide more aligned support to industry.
- **The bipartisan Geothermal Power Opportunity With Expanded Regions (Geo POWER) Act** (Hickenlooper-Daines, March 2026) would establish a Milestone-Based Geothermal Demonstration Program using innovative financing (including Other Transactions authority) to fund projects in new geologies and regions, with an emphasis on data generation and private capital mobilization. The bill provides legislative architecture; the Appraisal Risk Program provides a concrete operational framework for an early phase of implementation.

EGS provides 24/7 dispatchable baseload power from an entirely domestic resource, leverages U.S. oil and gas workforce and industrial capabilities, and supports the power supply growth demanded by AI infrastructure and electrification. A targeted federal investment here would crowd in private capital at multiples of the public commitment.

We propose a **Geothermal Appraisal Risk Program** that provides concessionary support for resource-appraisal drilling across a deliberately diversified portfolio of U.S. basins and geologies. The program proceeds in three stages: program design and mechanism selection, program execution ($200–$400M to fund appraisal drilling at 5–20 sites spanning diverse geologies and regions), and evaluation and knowledge transfer to connect appraised sites to the deployment pipeline.

THE PROGRAM PROCEEDS IN THREE STAGES

01

Program design and mechanism selection

02

Program execution

$200–$400M to fund appraisal drilling at 5–20 sites spanning diverse geologies and regions

03

Evaluation and knowledge transfer

to connect appraised sites to the deployment pipeline

A COHERENT PIPELINE · FROM SITE CONFIRMATION TO FULL-SCALE DEVELOPMENT

DE-FOA-0003472

Topic Area 6

Initial confirmation data at individual sites

→

MULTI-BASIN PORTFOLIO

Appraisal Risk Program

Confirmation across geologically diverse basins to shift institutional confidence

→

DEMONSTRATION PROGRAM

Geo POWER Act

Financing framework for projects that graduate from appraisal to full-scale development



02 The Case for Urgency

Geothermal power station in a high-temperature field, Krafla area, Iceland. **Photo: source to be confirmed**

EGS is approaching a tipping point. Costs are falling, demand for firm power is acute, and private capital is entering the space. Even with this positive momentum, significant exploration risks persist. Capital costs are high, resource availability is unknown, and insurance markets for exploration are nascent or non-existent. What the market lacks to unlock interested private finance is broad confirmation across geologies that EGS is a replicable, financeable resource. Traditional debt providers will not finance geothermal projects without a complete subsurface assessment; that kind of assessment requires the kind of expensive, high-risk capital that private markets won't deploy at scale without a federal backstop. Federal support isn't a substitute for private capital but rather creates the conditions that will make private capital possible.

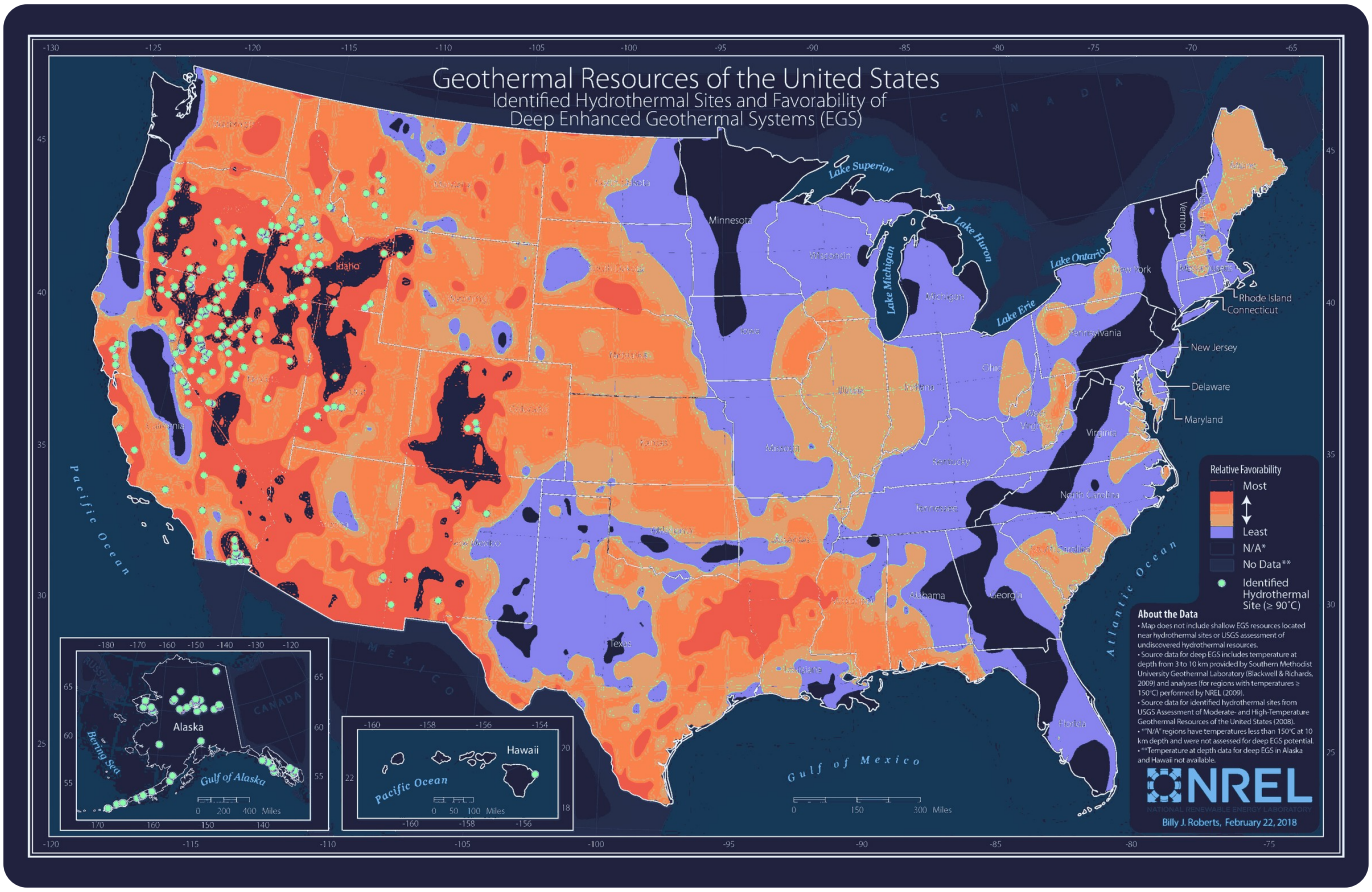
Two policy instruments are now in motion, creating a window for coordinated action. DOE's Topic Area 6 solicitation demonstrates the agency's recognition that resource confirmation and appraisal is a distinct and necessary investment. It supports the agency's emphasis on learning-by-doing, coordinating R&D efforts, and de-risking technologies. The Geo POWER Act signals bipartisan congressional support for innovative financing mechanisms that go beyond traditional cooperative agreements. Neither, on its own, achieves the geographic breadth and scale of appraisal needed to transform EGS from a promising technology into a standard energy development category. But together with a purpose-built appraisal program, they form a coherent pipeline: Topic Area 6 projects generate initial confirmation data at individual sites; the Appraisal Risk Program extends that effort to the multi-basin, geologically diverse portfolio that shifts institutional confidence; and the Geo POWER Act's milestone-based demonstration authority provides the financing framework for projects that graduate from appraisal to full-scale development.

Delay does not preserve optionality. It cedes market leadership to other countries and narrows the eventual scope of U.S. geothermal development.

03 Strategic Rationale

The technology has outpaced the financing. Next-gen geothermal technologies expand EGS's geographic reach across the entire United States and dramatically reduce the risk of resource confirmation compared to conventional approaches. But traditional capital will not fully participate without appraisal data from diverse geologies, data that requires drilling campaigns costing tens of millions of dollars per site.

WHERE THE RESOURCE IS · FAVORABILITY OF DEEP EGS ACROSS THE UNITED STATES



Source: NREL, *Geothermal Resources of the United States — Identified Hydrothermal Sites and Favorability of Deep Enhanced Geothermal Systems (EGS)*, Billy J. Roberts, February 22, 2018.

The market cannot quickly close this gap on its own. Private capital is entering the appraisal stage, including institutional commitments and financing with return expectations. These are positive developments, but insufficient to fund confirmation across the number and diversity of sites needed to shift market-wide confidence.

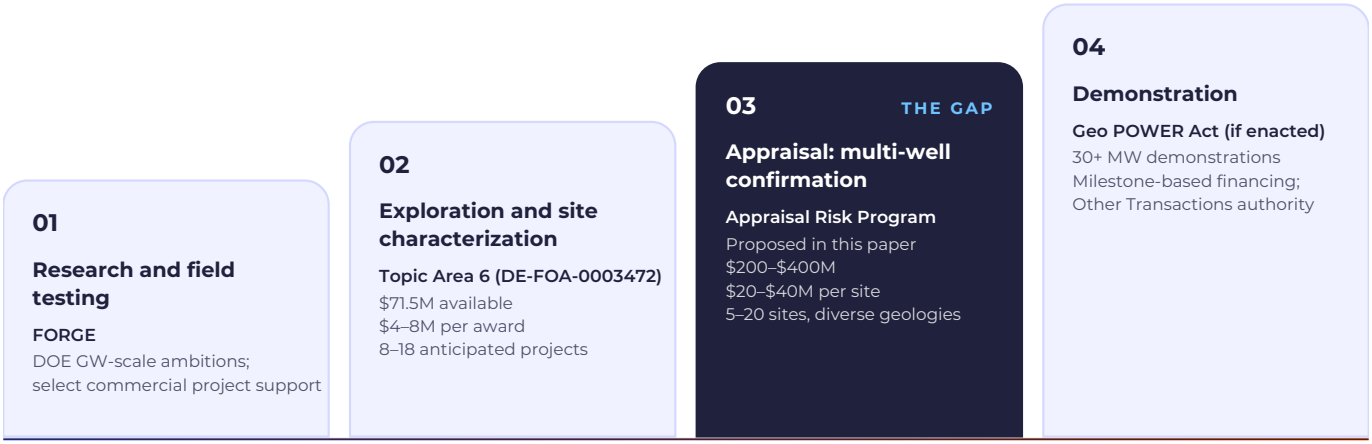
Existing federal programs address the gap, but not at scale. DOE has signaled GW-scale geothermal ambitions through FORGE and select commercial project support. The new Topic Area 6 solicitation (DE-FOA-0003472) represents the most direct federal investment in resource

confirmation to date, with $71.5 million available for exploration, characterization, and confirmation drilling. This is a meaningful step. However, the program operates within the cooperative agreement framework at award sizes ($4–8M) that support individual site characterization rather than the $20–40M multi-well appraisal campaigns. Multi-well campaigns are what is required to generate decision-grade confirmation data at any given site and characterize learning rates towards ultimate well costs. The portfolio of Topic Area 6 awards will generate valuable data, but, by design, it will not provide the breadth of multi-basin confirmation needed to unlock institutional capital at scale.

Legislation is creating new authority. The Geo POWER Act would authorize DOE to deploy innovative financing for next-gen geothermal demonstrations in new regions, using milestone-based structures and Other Transactions authority. The bill's priorities align closely with this program concept: geographic and geological diversification, data generation as a condition of support, and catalyzing private investment. The Appraisal Risk Program could serve as a natural first-phase implementation vehicle for the authorities that the legislation would create, focusing on the confirmation stage that precedes the 30+ MW demonstrations the bill envisions.

Proven precedent. GRED demonstrated that federally supported appraisal drilling generates capacity and data assets that persist for decades. Internationally, risk-sharing drilling programs remain the most effective policy mechanism for accelerating geothermal deployment.

WHERE THE GAP SITS · FEDERAL SUPPORT BY DEVELOPMENT STAGE, AS DESCRIBED IN THIS PAPER



04 Proposed Solution

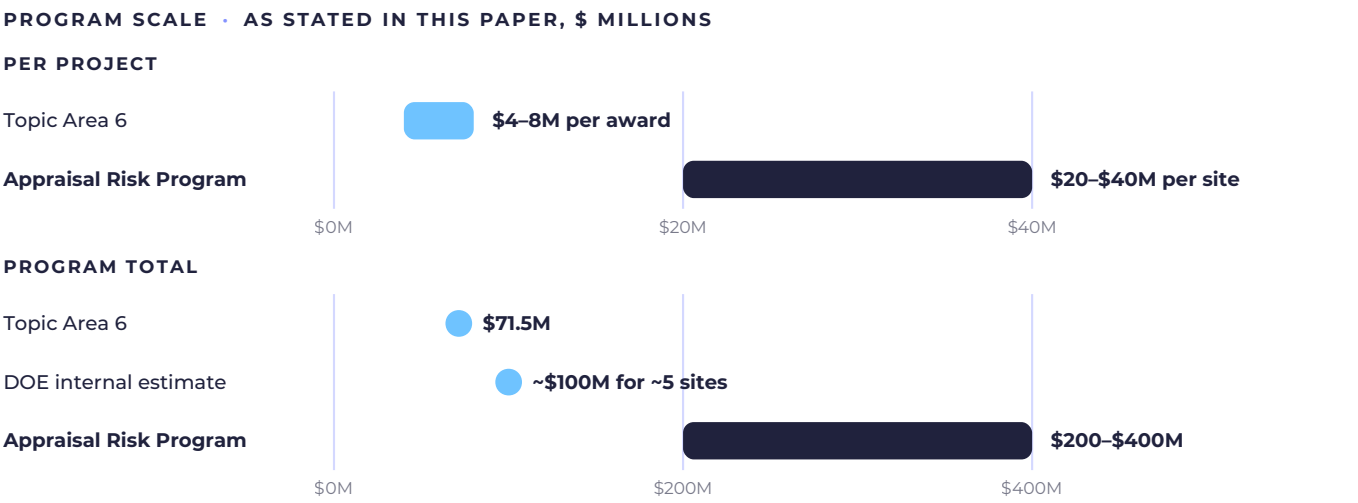


Drilling rig at the Utah FORGE enhanced geothermal field laboratory, Milford, Utah. **Photo: source to be confirmed**

The program would provide **concessionary financial support** for **appraisal drilling** across a deliberately **diversified portfolio of U.S. basins**, generating confirmation data and operating experience at the breadth necessary to shift market confidence in EGS. The portfolio must intentionally span diverse geologies and regions (proving EGS in one basin does not prove it in others), and site selection criteria should weigh geographic and geological diversity alongside technical merit. As a condition of support, all projects must contribute subsurface data to public repositories after a reasonable holding period, replicating GRED's most enduring legacy and creating information assets whose value compounds over time.

Scale. $200–$400M for appraisal risk. This range represents the target exposure — capitalization structure and totals may vary depending on final program design and structure. At $20–$40M per site, this initially supports campaigns at 5–20 locations depending on cost-share and geology. This is sized larger than DOE's internal estimates of ~$100M for ~5 confirmation sites, reflecting the geographic breadth central to this concept. It is complementary to the $71.5M in Topic Area 6 funding, which operates at a different (earlier) stage and smaller per-project scale. The program structure could also be replicated across mineral exploration and other subsurface resource development efforts.

Eligibility. Projects must demonstrate technical documentation of resource potential, developer capacity, and commitment to data sharing. Cost-share requirements should be calibrated to the selected instrument(s) during the design phase, with flexibility for small and emerging developers. Projects that have completed or are completing Topic Area 6 characterization work should be eligible for appraisal-stage support, creating a clear federal pipeline from exploration to confirmation to demonstration.



Mechanism. The program is mechanism-agnostic by design. The optimal instrument, or combination of instruments, should be determined in the design phase rather than assumed at the outset. Viable options include:

01

Cooperative agreements

simplest to execute; strongest fit for uncharacterized basins; consistent with Topic Area 6 framework, but at a larger per-project scale

02

Concessionary loans or loan guarantees with outcome-calibrated terms

potential for a revolving fund structure

03

Other Transactions authority

flexible terms and faster execution; directly enabled by the Geo POWER Act if enacted

04

Blended approaches

that match instruments to site-level risk profiles

Each carries different tradeoffs in execution speed, administrative burden, IP treatment, and potential for federal return. The design phase should evaluate these systematically, informed by the Geo POWER Act's emphasis on milestone-based structures and by the practical experience gained from Topic Area 6 awards.

Execution model. Prioritize speed; avoid creating permanent federal infrastructure for a time-limited activity. Options include a joint Geothermal Office (GO)-OCED funding opportunity, execution through an intermediary (FESI or a national laboratory consortium), or a Prize/Innovation Authority (PIA) structure. National laboratories should be leveraged for technical validation, modeling, and data management. GO, OCED, and EDF should be involved in design and evaluation regardless of execution vehicle.

05 Relationship to Current Policy

Complementing Topic Area 6 (DE-FOA-0003472). The Appraisal Risk Program is designed to amplify, not duplicate, DOE's existing solicitation. Topic Area 6 fills a critical need for initial resource characterization at individual sites, with awards sized for exploration-stage drilling and data collection. The Appraisal Risk Program operates at the next level of investment: multi-well confirmation campaigns at sites where initial characterization data already suggest viability. Topic Area 6 projects are natural feeders into the appraisal portfolio, and the data-sharing requirements that both programs emphasize create a compounding public knowledge base.

The programs also differ in geographic strategy. Topic Area 6 prioritizes previously unexamined formations and locations but selects projects individually based on technical merit. The Appraisal Risk Program would deliberately construct its portfolio for geographic and geological diversity, ensuring that confirmation data span the range of settings where EGS deployment is commercially relevant.

Implementing the Geo POWER Act. The legislation's Milestone-Based Geothermal Demonstration Program would require DOE to award innovative financing to projects in low-permeability and impermeable reservoirs through a competitive process, prioritizing new regions and geologies, data generation, and projects with potential to attract private investment. The Appraisal Risk Program maps directly to these priorities:

- The program's multi-basin portfolio approach satisfies the Act's requirement to fund projects in at least 3 different states with at least 3 different sponsors.
- The data-sharing requirements align with the Act's emphasis on generating public data to de-risk future projects.
- The program's concessionary appraisal support would build the evidence base confirming the 30+ MW demonstration projects the Act envisions.
- The design phase could evaluate how milestone-based structures and OT authority (as authorized under Section 9005 of the Energy Act of 2020, referenced in the bill) apply specifically to appraisal-stage investments.

AMPLIFY, NOT DUPLICATE · HOW THE TWO PROGRAMS DIFFER

DE-FOA-0003472

Topic Area 6

Stage	Initial resource characterization at individual sites
Award size	$4–8M per award
Program total	$71.5M
Projects	8–18 anticipated projects
Selection	Projects selected individually on technical merit; prioritizes previously unexamined formations and locations

FEEDS INTO

PROPOSED

Appraisal Risk Program

Stage	Multi-well confirmation campaigns at sites where initial data already suggest viability
Per site	$20–$40M per site
Program total	$200–$400M
Sites	5–20 sites
Selection	Portfolio deliberately constructed for geographic and geological diversity

06 Anticipated Impact and Value

The program succeeds if it builds sufficient confidence, across geologies and regions, that institutional capital enters EGS appraisal at scale. This means proving development approaches are viable in multiple, diverse locations, shifting market perception from "novel technology" to "replicable energy development."

Developers gain concessionary capital at the scarcest stage. Capital providers gain access to a growing body of subsurface data, which improves underwriting. The public gains a national subsurface information asset, workforce, and supply chain development across regions, and accelerated deployment of firm, dispatchable power from an entirely domestic resource that leverages existing oil and gas capabilities.

Key success indicators:

Category	Indicators
Resource appraisal	Sites appraised; MW confirmed; distinct geologies represented
Market confidence	Private capital mobilized per federal dollar; cost-of-capital trends; projects advancing to production financing
Data development	Subsurface data contributed to public repositories
Policy alignment	Topic Area 6 projects advancing into appraisal portfolio; milestones achieved under Geo POWER Act authorities

07 Next Steps

We recommend convening a working session with DOE program leadership (GO, OCED, EDF), national laboratory partners, geothermal developers, and financial intermediaries to assess program design options and coordination with Topic Area 6 awards. With the goal of a fully specified operational plan that can move to a go/no-go decision point, this session would evaluate trade-offs in mechanisms, define diversification criteria, and identify the funding authority, including how the program could serve as an early implementation vehicle for the Geo POWER Act, if enacted.

THE PIPELINE THIS PROGRAM COMPLETES · FROM SITE CONFIRMATION TO FIRM POWER

Exploration
Topic Area 6: initial confirmation data at individual sites

Appraisal
Appraisal Risk Program: multi-well confirmation across diverse basins

Demonstration
Geo POWER Act: 30+ MW projects in new regions and geologies

Production financing
Appraised sites advance to production financing

Firm, dispatchable power
24/7 baseload from an entirely domestic resource



GEOTHERMAL APPRAISAL RISK PROGRAM

Appendices

A

APPENDIX A

Implementation Stages

B

APPENDIX B

Key Appraisal Data Parameters



A

APPENDIX

Implementation Stages

01 Stage 1 — Design

- **Commission the design effort.** Evaluate key objectives and requirements, instrument options (with particular attention to milestone-based structures and OT authority consistent with the Geo POWER Act), and key partners and third-party experts. Define diversification and site selection criteria, and produce a fully specified operational plan with a go/no-go decision point.
- **Engage stakeholders.** Convene GO, OCED, EDF, and national lab partners. Validate with industry, financial intermediaries, and Hill staff. Inform FY27/FY28 appropriations processes and Geo POWER Act implementation planning.
- **Assess coordination with Topic Area 6.** Identify how existing and anticipated Topic Area 6 awards can feed into the appraisal portfolio and define the data and milestone criteria that would qualify a site for appraisal-stage support.

02 Stage 2 — Execution $200–$400M

- Deploy appraisal support to a geographically diverse portfolio. Implement data-sharing from day one. Leverage national labs for validation and data management.

03 Stage 3 — Evaluation CONCURRENT AND FOLLOWING

- Publish data and outcomes. Assess the impact on market confidence and capital mobilization. Ensure appraised sites connect to demonstration and production pathways, including any projects funded under the Geo POWER Act authorities.

B

APPENDIX

Key Appraisal Data Parameters

A standardized data collection framework is essential if the Appraisal Risk Program is to generate portfolio-level learning, not just site-level confirmation. The parameters below represent the minimum comparable dataset that should be required across all funded projects. When collected consistently and contributed to public repositories, these data enable cross-project learning curves, technology benchmarking, and progressive improvement in underwriting confidence across geologies.

Note: This is a preliminary list that should be refined in collaboration with industry and government experts prior to implementation.

The parameters are scoped to the appraisal stage at which they are collected: pre-drill characterization, confirmation well drilling, and initial post-drill testing sufficient to determine site viability. Parameters associated with extended production testing, long-term reservoir sustainability monitoring, and full-scale demonstration are excluded.

FOUR DATA PHASES · 16 PARAMETER CATEGORIES, SCOPED TO THE APPRAISAL STAGE

01

Pre-drill characterization

4 CATEGORIES

Establishes the conceptual geologic model and development hypothesis

02

Drilling and well construction

5 CATEGORIES

The highest-value operational dataset for driving cost curves

03

Post-drill testing

5 CATEGORIES

The highest-value dataset for reducing appraisal risk

04

Cross-cutting (all phases)

2 CATEGORIES

Essential for portfolio-level learning and cost reduction

Pre-drill characterization

Establishes the conceptual geologic model and development hypothesis against which all subsequent drilling and testing results are compared. Standardized documentation of pre-drill predictions across sites is the foundation for improving resource assessment methods across geologies.

Parameter Category	Key Parameters	Rationale
Integrated geologic model	Lithology and stratigraphy; structural geology (faults, fractures, stress regime); reservoir geometry and depth targets; thermal regime (gradients, heat flow); evidence of permeability or fluid pathways; prior well data	Frames all subsequent drilling and testing decisions. Comparison of pre-drill models to actual outcomes across the portfolio improves resource assessment methods.
Surface and geophysical datasets	Geological mapping; geophysical surveys (seismic, MT, gravity); geochemical indicators (fluid/gas seeps, geothermometers); thermal gradient data from shallow wells	Underpins confirmation well siting. Consistent survey methods and reporting build a national-scale picture of which surface indicators are predictive in which geologic settings.
Pre-drill reservoir estimates	Estimated temperature, pressure, permeability, and fracture density at depth; in-situ stress orientation and magnitude (modeled or inferred)	Captures the baseline prediction against which drilling results are measured. Systematic pre-drill vs. post-drill comparison across the portfolio generates calibration data for future resource models.
Development hypothesis	Expected flow rates and thermal output; power potential estimate; development concept (EGS, hydrothermal, closed-loop)	Documents the commercial thesis for each site. Required to evaluate whether appraisal results confirm, modify, or reject the development case.

Drilling and well construction

The highest-value operational dataset for driving cost curves and establishing repeatability. Standardized drilling and construction data across geologies enable benchmarking, identify which techniques transfer between settings, and quantify the learning rate for EGS well construction.

Parameter Category	Key Parameters	Rationale
Drilling performance	Rate of penetration vs. depth; bit performance; drilling time per interval; non-productive time and causes; torque and drag; mud parameters; circulation losses	Core data for constructing EGS drilling cost curves across geologies. Enables identification of transferable efficiency gains.
Well construction and completion	Well trajectory; casing design, depth, and cementing quality; diameter and completion configuration; zonal isolation approach	Documents the engineered system. Comparability across projects enables assessment of which completion strategies perform in which geologic environments.

Parameter Category	Key Parameters	Rationale
Subsurface measurements (MWD/ LWD/logging)	Temperature (real-time and corrected); pressure; lithology logs (gamma, resistivity); porosity indicators; fracture indicators (image logs, caliper)	Validates or revises the pre-drill geologic model in real time. Consistent logging suites across projects build the comparative subsurface dataset that is the program's core public asset.
Core and cuttings analysis	Mineralogy; porosity and permeability (lab-measured); mechanical properties (strength, brittleness); alteration and hydrothermal signatures	Ground-truth data for reservoir properties that cannot be fully characterized from logs alone. Lab-measured values from diverse geologies reduce uncertainty in future resource models.
Geomechanical parameters	In-situ stress measurements (DFIT, leak-off tests); elastic properties (Young's modulus, Poisson's ratio); fracture gradient	Among the most consequential and least available inputs for EGS design. Every additional stress measurement from a new geologic setting reduces uncertainty for subsequent projects in similar formations.

Post-drill testing

The highest-value dataset for reducing appraisal risk. These measurements determine whether a site advances to development financing and, collected across the portfolio, build the statistical evidence base that shifts institutional confidence in EGS as a resource class. Parameters here are scoped to initial well testing, not extended production or reservoir sustainability monitoring.

Parameter Category	Key Parameters	Rationale
Temperature characterization	Equilibrated temperature profile vs. depth; transient temperature recovery curves	Confirms the thermal resource with measured (not modeled) data. Consistent profiles across the portfolio define the temperature map of U.S. EGS potential.
Flow, productivity, and initial thermal performance	Flow rates (mass and volumetric); injectivity and productivity indices; pressure drawdown/buildup curves; reservoir pressure; inlet and outlet temperatures; heat extraction rate	The primary confirmation dataset. Cross-project flow data enable capital providers to build statistical confidence in EGS productivity across geologies. Translates subsurface conditions into energy output. Provides the basis for projecting commercial thermal and electrical potential.
Permeability and connectivity	Effective permeability (measured or inferred from well tests); fracture network connectivity (where stimulation is part of the confirmation program)	Connects well test results to reservoir behavior. Consistency in derivation and reporting enables meaningful comparison across the portfolio.
Fluid geochemistry	Fluid composition (major ions, gases); scaling and corrosion potential; phase behavior	Defines operational constraints for future development. Geochemical data from diverse formations inform materials selection and operational planning for subsequent projects.

Parameter Category	Key Parameters	Rationale
Thermal conductivity and heat capacity	Thermal conductivity profile (from core samples or logs); heat capacity	Required for accurate resource modeling and performance prediction. Measured values from real formations replace the assumed values that currently dominate EGS techno-economic models.

Cross-cutting (all phases)

These parameters are often overlooked but are essential for portfolio-level learning and cost reduction. Without standardized cost and operational data across projects and geologies, the industry cannot demonstrate the learning rates that attract institutional investment.

Parameter Category	Key Parameters	Rationale
Time and cost data	Cost per foot drilled; time per section; cost breakdown by activity	Essential for constructing the EGS cost curves that capital markets require.
Operational decision logs	Changes in drilling or testing approach; lessons learned; failure modes	Captures the tacit knowledge that drives operational improvement. Structured documentation of what was tried, what worked, and what failed is the mechanism through which portfolio-level learning compounds.

Minimum comparable dataset

The core set that should be standardized across all projects to enable project-level appraisal, cross-project learning curves, and cost benchmarking:

01 Temperature vs. depth (equilibrated)
02 Pressure vs. depth and transient tests
03 Flow rate, injectivity, and productivity
04 Thermal output (inlet/outlet temperatures)
05 Lithology and fracture characterization
06 Stress measurements
07 Permeability (measured or inferred)
08 Thermal conductivity
09 Fluid chemistry
10 Drilling performance (ROP, NPT, cost)