SEPTEMBER 2025

Next-Generation Geothermal

Leveraging a Strategic Opportunity for U.S. Energy Leadership

By Ray Cai and Rebecca Riess

Introduction

In a shifting global geostrategic landscape, the dual challenges of **rising** electricity demand and **intensifying** energy security imperatives highlight the need for efficient, resilient, and affordable energy innovations to underpin long-term technological and economic competitiveness. In this context, **next-generation geothermal energy**—engineered to harness the Earth's heat as a replenishable, reliable, and flexible power source—offers a unique opportunity for renewing U.S. energy leadership in a strategic industry at a potential inflection point.

As a pioneer in developing and commercializing next-generation geothermal systems, the United States possesses distinct comparative advantages across the value chain. If the industry successfully scales up, the United States is well-positioned to capture commercial opportunities, advance diplomatic objectives, and reaffirm its innovation leadership—all while enabling broader global development needs and energy objectives. To capitalize on its first-mover advantage and the strategic opening, the United States should proactively spearhead the international deployment of next-generation geothermal systems through sector-level engagement and pilot projects.

CSIS | CENTER FOR STRATEGIC & INTERNATIONAL STUDIES

Why Next-Generation Geothermal Could Be a Game Changer

Conventional geothermal, or hydrothermal, systems rely on the rare natural convergence of three key subsurface conditions: sufficient heat, permeable rock formations, and circulating groundwater. This geological trifecta is typically found only in select regions, severely **contraining** where conventional geothermal can be deployed. Even in optimal locations, hydrothermal systems face additional barriers, including low **conversion efficiency**, cost **uncertainties**, and long **development timelines**. As a result, conventional geothermal currently contributes less than 0.5 percent of total electricity generation globally. While over 30 countries maintain some level of geothermal capacity, only six **derive** more than 10 percent of their electricity from the resource.

In contrast, next-generation geothermal systems **leverage** novel technologies and engineering practices to overcome the geographic and geologic constraints that have long limited hydrothermal. By reducing dependence on naturally occurring subsurface conditions, next-generation systems could dramatically expand geothermal deployment across a broad range of geographies. With potentially modular, repeatable designs, these systems could also transform geothermal project economics through rapid learning, continuous performance improvements, and cost reduction across wells and projects.

A variety of emerging technologies and practices fall under the umbrella of next-generation geothermal. They usually involve a combination of innovative drilling, fracturing, or fluid injection techniques at deeper depths, in hotter environments, or in rock formations that lack natural permeability or groundwater circulation.

Table 1.1: Geothermal Technologies

Less mature →

	Next-Generation Geothermal		
Conventional Hydrothermal	**Enhanced Geothermal Systems (EGS)**	**Advanced Closed-loop Geothermal Systems (AGS)**	**Geopressured Geothermal Systems (GGS)**
Utilize naturally occurring hot rock, permeability, and fluid circulation	Engineer artificial fissures and circulation via stimulation and injection	Engineer closed-loop circuits and utilize heat via conduction	Utilize heat in over-pressured sedimentary basins
TRL: 8+	TRL: ~7	TRL: ~6	TRL: ~5
	Potential to access heat in high-temperature (> 370C) superhot rock (SHR)		
	TRL: ~5		

Note: TRL denotes technology readiness level; a TRL of 8 indicates readiness for full commercial deployment.

Source: Department of Energy.

Table 1.2: Plant Type

Deeper underground / higher temperature →

Direct use: <100C	Binary cycle: >100C	Dry steam: >150C	Flash steam: >180C

Note: Flash steam systems are mostly used in legacy plants.

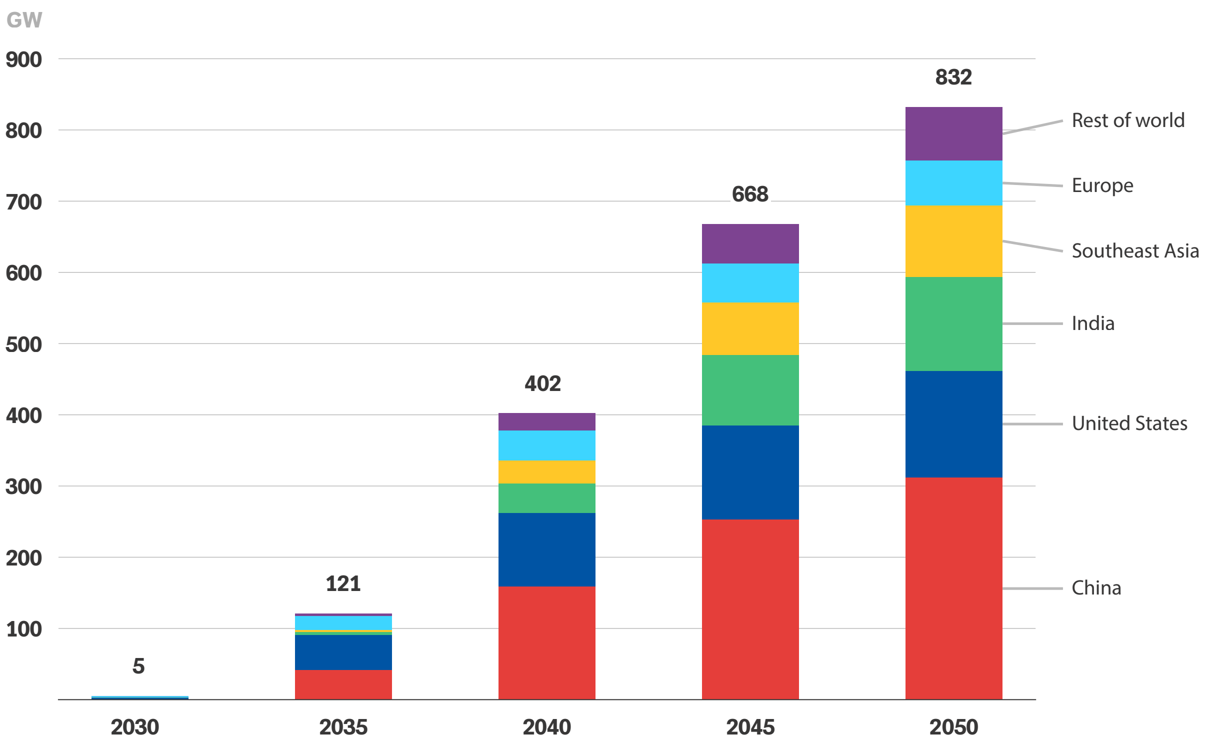
Source: Department of Energy.

This white paper explores how next-generation geothermal energy can serve as a strategic lever for U.S. energy leadership. The first section evaluates the value proposition of next-generation geothermal to U.S. national interests. The second section assesses the current U.S. competitive position across the industry value chain. The final section offers a policy framework for scaling international deployment through U.S.-led sector-level engagement and pilot projects.

A STRATEGIC OPPORTUNITY ACROSS THREE DIMENSIONS

Next-generation geothermal offers U.S. firms across the value chain access to a fast-growing global market. The International Energy Agency (IEA) **estimates** that the global market for next-generation geothermal could reach 120 gigawatts (GW) by 2035 and over 800 GW by 2050, or about 8 percent of global electricity supply. Additionally, the industry could catalyze broad economic growth by stimulating demand across related sectors (see the value chain section below). The total cumulative U.S. serviceable addressable market–the portion of total demand that could be feasibly accessed–for geothermal from 2020 to 2050 is **projected** to be as high as $1.5 trillion and associated with about 100,000 U.S. jobs.

Figure 1: Total Next-Generation Geothermal Market Size (GW)



Source: IEA.

Beyond its commercial potential, next-generation geothermal can serve as a tool of diplomatic engagement. Its attributes constitute a unique value proposition to countries seeking to expand and secure their energy supply mix. Many partner countries have high resource potential for deployment but may lack technical expertise or capital to develop it independently. U.S. support can bridge this gap–fostering goodwill, strengthening ties, and enabling partner countries to participate in emerging U.S.-led value chains. These long-term, strategic relationships in turn advance U.S. national interests abroad.

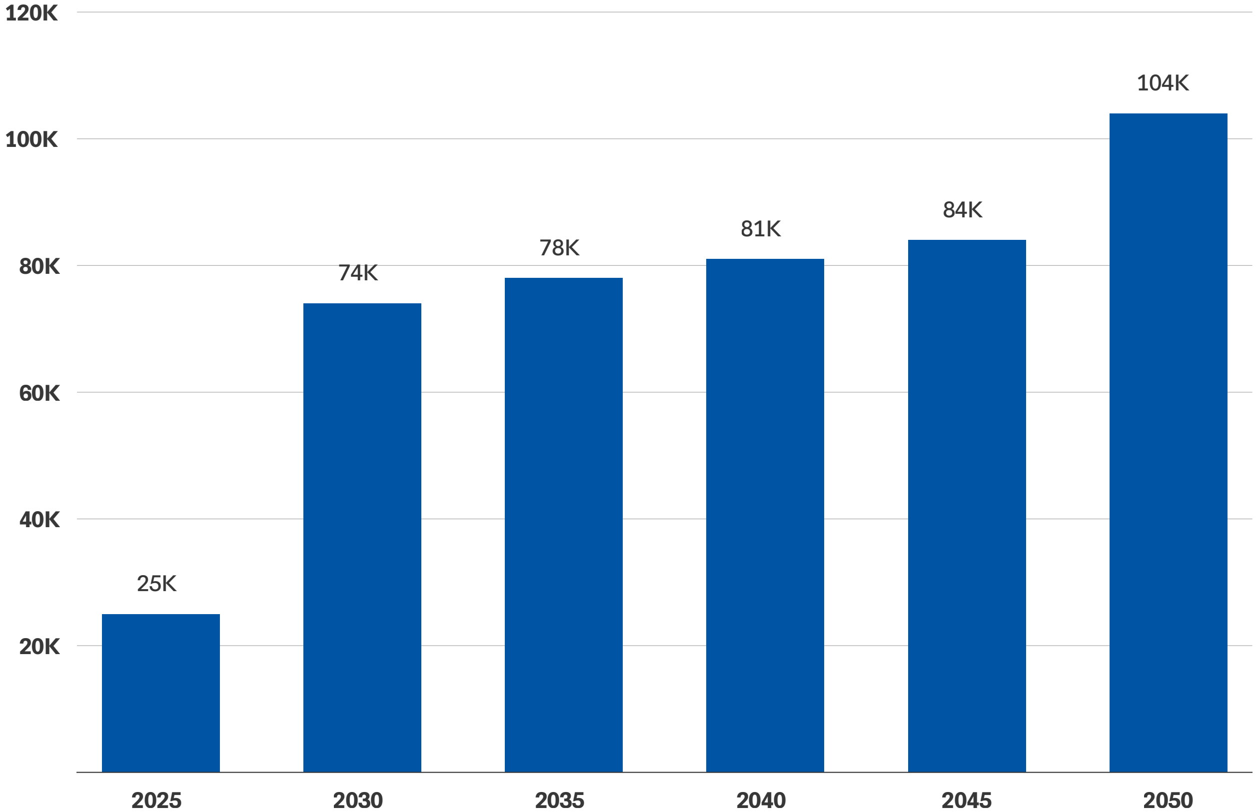
Table 2: Value Proposition of Next-Generation Geothermal

Attribute	Description	Value Proposition
Firm and dispatchable	Reliable 24/7 baseload energy that can be flexibly dispatched	Enhances grid reliability
Minimal land footprint	Requires much less land per megawatt (MW) than solar, wind, natural gas, and coal	Ideal for countries with land constraints or competing land-use priorities
No fuel cost/dependence	No ongoing fuel inputs required once operational	Reduces exposure to fuel price volatility or import dependence
Geographic scalability	Potentially broad geographic availability and accessibility	Offers countries access to previously unavailable resources
Supply chain diversification	The geothermal supply chain is distinct from most renewables	Provides an alternative to countries concerned about supply chain dependency on China
Low emissions	Geothermal operations emit low levels of greenhouse gases and criteria air pollutants	Mitigates public health impacts and helps achieve decarbonization goals

Source: Department of Energy; author's analysis.

Crucially, next-generation geothermal draws on and reinforces multiple pillars of U.S. technological, industrial, and financial comparative advantages. Cementing leadership in the sector would provide a crucial boost to the U.S. energy innovation ecosystem. As competition over global energy leadership intensifies, a strong U.S. presence in geothermal **signals** its capacity and commitment to pioneer, scale, and export transformative innovations.

Figure 2: Projected Cumulative Jobs Created (thousands of job-years)



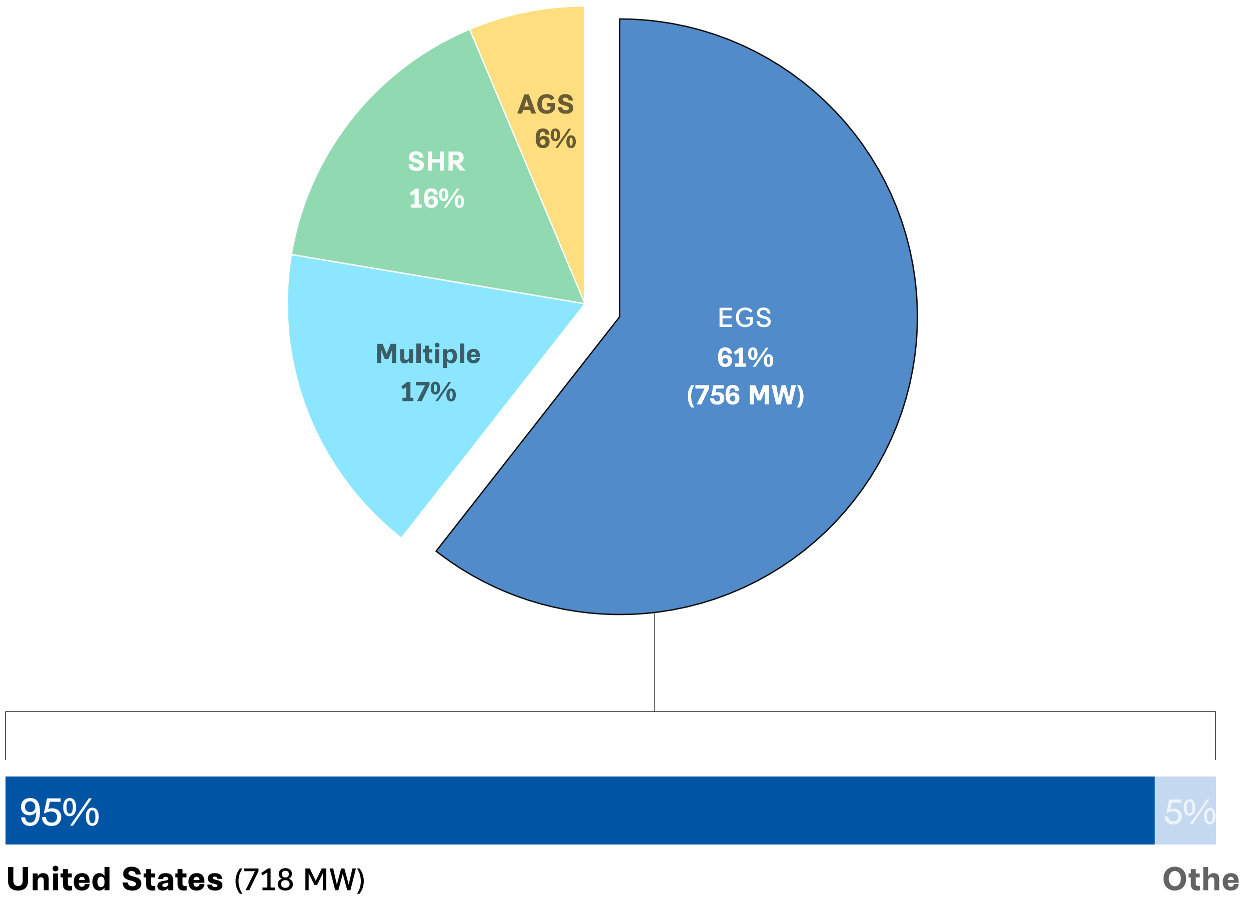
Source: BCG (based on 2022 IEA projections).

Assessing U.S. Competitive Positioning

FROM PIONEER TO PACESETTER

Since the Nevada Fenton Hill project first **demonstrated** artificial reservoirs in the 1970s, the United States has remained a pioneer in geothermal innovation through initiatives including the Utah **Frontier Observatory for Research in Geothermal Energy (FORGE)**. Commercial next-generation geothermal operations outside the United States, such as the 1.7 MW **Soultz-sous-Forêts project** in France and the 4.8 MW **Insheim plant** in Germany, are dwarfed by the scale of U.S. projects. In fact, three U.S. projects under development account for 95 percent of total global EGS capacity today.

Figure 3: Total Next-Generation Capacity (MW) Operating and Under Development, by Technology and Country



Source: Wood Mackenzie.

U.S. projects have achieved industry-leading technical performance. The FORGE research site achieved an over 500 percent improvement in drilling speed and 194 percent longer bit life from its 2017 baseline. Fervo Energy's Cape Station and Project Red are on track to become the first commercial projects to achieve a rate of penetration (ROP) of 9.4 meters per hour. Cape Station **reached** a record-setting flow rate of 107 kilograms per second, nearly triple the industry **average**. Project Red also recorded zero thermal decay after one year of operations–a milestone that strengthened long-term project viability and helped overcome a key barrier to financing.

Table 3: Key Next-Generation Geothermal Technical Performance Indicators

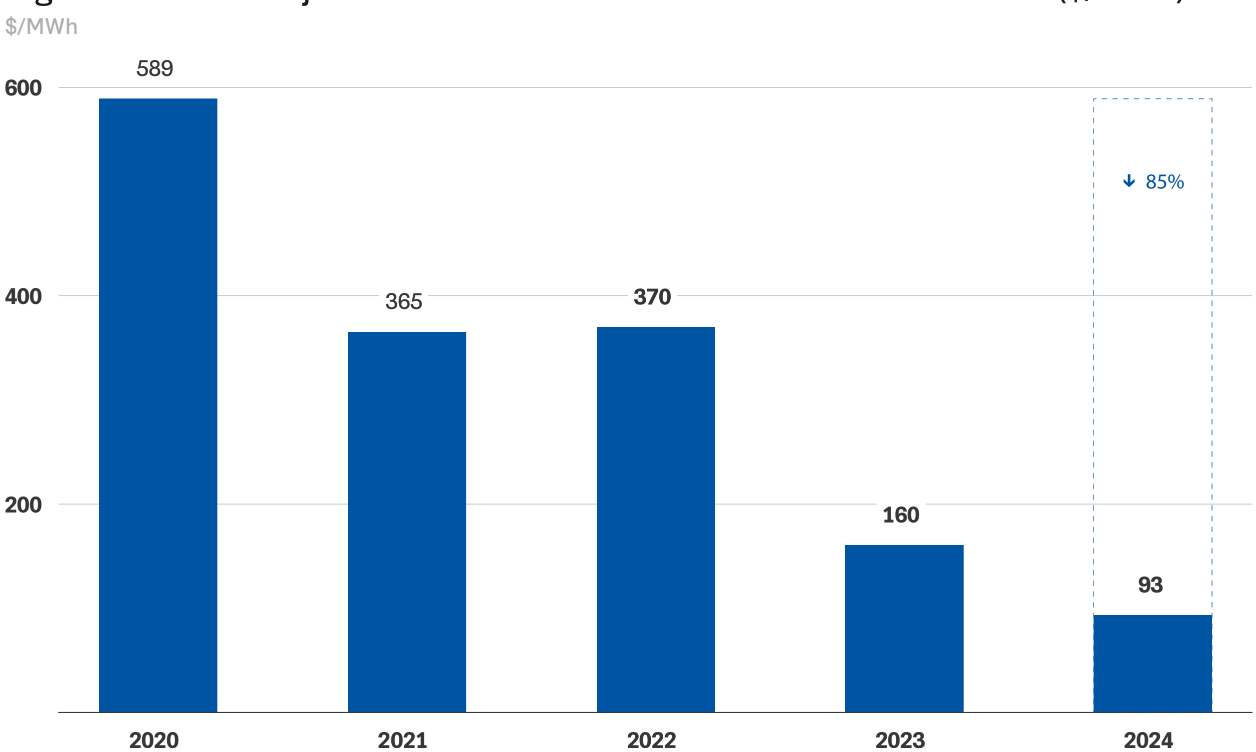
Key Performance Indicator	Description
Drilling cost	Total drilling cost per foot
Well cost	Total cost per well
Levelized cost of electricity	Proxy for overall cost of production
Spud to total depth	Days from drilling initiation to target depth
Rate of penetration	Drilling speed in meters per hour
Bit life	Drilling bit operational duration before failure

Key Performance Indicator	Description
Lateral length	Length of horizontal well segment/ heat exchange surface area
Flow rate	Volumetric flow per second
Temperature	Production fluid temperature
Enthalpy	Energy content of fluid
Thermal decay	Annual production decline
Capacity factor	Ratio of average delivered power to the theoretical capacity of the facility.

Source: Author's analysis.

Technical breakthroughs have reshaped expectations of economic viability. Recent U.S. commercial deployments, for instance, **reported** an estimated learning rate (the fractional gain in efficiencies for each doubling of cumulative production) of 35 percent between wells. For reference, the industry-wide learning rate **observed** in unconventional gas hydraulic fracturing projects was 13 percent between 2005 and 2015. The National Renewable Energy Laboratory (NREL) has substantially revised its levelized cost of energy (LCOE) forecast for next-generation geothermal to reflect recent cost reductions. Between the 2020 and 2024 editions of NREL's Annual Technology Baseline (ATB) model, the projected LCOE for EGS in 2025 decreased by nearly 85 percent.

Figure 4: NREL Projected 2025 Next-Generation Geothermal LCOE ($/MWh)



Note: Based on "moderate case" ATB projections for EGS projects using binary turbines and tax credits where available.

Source: National Renewable Energy Laboratory.

DEEP DIVE: U.S. LEADERSHIP ACROSS THE VALUE CHAIN

A clear understanding of the next-generation geothermal value chain is essential to identifying the segments where the United States holds, or is uniquely positioned to develop, global leadership. This clarity helps guide how the United States can most effectively leverage its capabilities to foster the global deployment of next-generation geothermal, as well as high-impact segments for U.S. strategic interests.

Figure 5: Key Value Chain Segments

Suppliers

Raw Materials and Inputs	• Extracting and processing raw materials needed for projects • U.S. serviceable addressable market (SAM), 2020–2050: \$10–15 billion
Original Equipment Manufacturing (OEM)	• Manufacturing and assembling subsurface and surface equipment • U.S. SAM, 2020–2050: \$130–175 billion

Providers

Project Development	• Developing the project from origination to operation • U.S. SAM, 2020–2050: \$340–460 billion
Equipment, Procurement, and Construction (EPC)	• Servicing project development needs • U.S. SAM, 2020–2050: \$170–230 billion
Operations/Maintenance	• Operating and maintaining subsurface and surface assets • U.S. SAM, 2020–2050: \$310–420 billion

Enablers

Financing	• Providing capital for projects • U.S. SAM, 2020–2050: \$280–380 billion
Legal and Other Services	• Providing specialized support services for projects
Offtake	• Providing offtake for projects

Source: BCG; author's analysis.

Suppliers

Supply chain resilience has proven to be vital for the long-term viability of innovative energy technologies. A robust industrial base, complemented by innovation, has given the United States a competitive edge in subsurface equipment. However, upstream material dependencies–particularly in the face of global trade dynamics–pose risks that could hinder the U.S. geothermal sector's international competitiveness.

The United States **benefits** from a robust domestic manufacturing base and innovation ecosystem rooted in decades of oil and gas leadership. U.S. OEMs supply critical equipment such as drilling rigs, well casing, downhole tools, monitoring and control systems, and reservoir modeling software. U.S. next-generation geothermal developers, for instance, could access high-performance polycrystalline diamond compact (PDC) **drill bits** and the world's largest and most technically advanced **fleet** of onshore drilling rigs. Further innovation in technologies such as plasma drills, environment-resistant downhole equipment, and artificial intelligence (AI)-enabled software solutions can accentuate the United States' competitive advantage.

At the same time, upstream material dependencies present latent risks to the international competitiveness of U.S. geothermal OEMs. Essential components such as steel casing and drilling liquid are vulnerable to tariffs, trade restrictions, **competing demand**, and other supply disruptions. Cost volatility and availability constraints could thus make it harder for U.S. firms to compete on price and delivery timelines. Six of the ten minerals most relevant for geothermal are **considered** critical, for instance, with four currently dependent on imports.

Table 4: Critical Minerals Import Dependence

Material	Import Dependence in 2024
Neodymium	95%
Titanium	86%
Molybdenum	80%
Chromium	77%
Nickel	48%
Aluminum	47%
Copper	Non-critical/not reported
Epoxy	Non-critical/not reported
Carbon	Non-critical/not reported
Iron	Non-critical/not reported

Source: USGS.

The United States also faces gaps in surface power plant equipment as it remains a net importer. Supply chain vulnerability is evident in the case of transformers, where supply chain bottlenecks are **well documented**, and **Organic Rankine Cycle (ORC)** turbines, which are currently the dominant technology for binary-cycle plants. The global ORC market remains concentrated and **dominated** by a handful of non-U.S. incumbents; most U.S. ORC turbines are imported and custom designed for each project, resulting in procurement lead times that can exceed 18 months.

Figure 6: Key Geothermal Power Plant Equipment Import Dependence

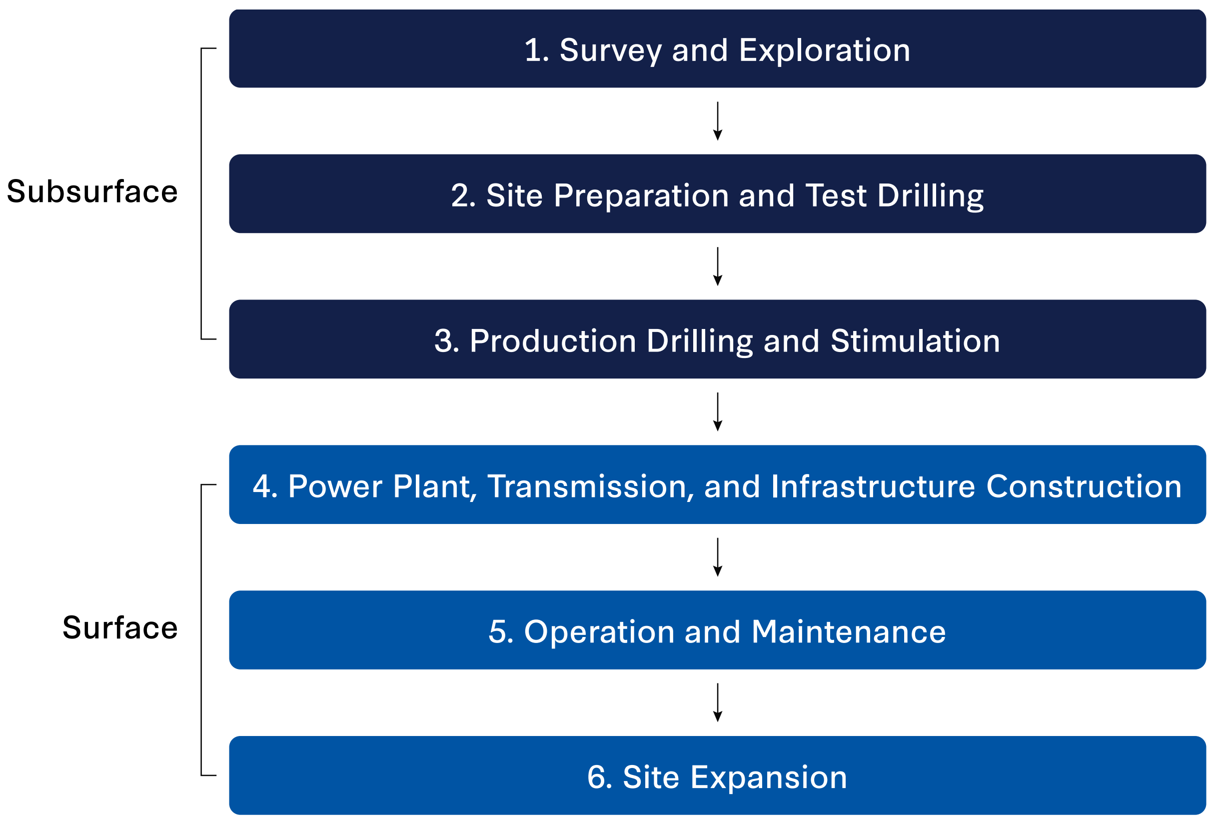
Note: Figure shows 2020–2024 average percentages.

Source: UN Comtrade; author's analysis.

Providers

The United States holds a commanding lead in next-generation geothermal project development–arguably the most critical and value-intensive segment of the value chain. Decades of oil and gas innovation have created an ecosystem of transferable technical knowledge, operational expertise, and workforce skills that give U.S. developers a global edge. According to the International Energy Agency, transferring oil- and gas-derived productivity gains to geothermal could **reduce** next-generation project costs by up to 80 percent.

Figure 7: Key Project Development and Operation Steps



Source: Author's analysis.

Success in geothermal project development begins with accurate and efficient resource characterization, a high-risk and capital-intensive stage. Industry data suggests that only 16 to 21 percent of geothermal exploration efforts advance from confirmation drilling to commercial-scale production. U.S. developers benefit from a deep **foundation** of subsurface data and exploration expertise accumulated over decades of **public-backed** resource mapping and private oil, gas, and mineral extraction.

This U.S. dominance in unconventional hydrocarbons translates to geothermal drilling and stimulation. The United States is one of only four countries capable of **commercial** shale gas production. As of 2023, **64 percent** of U.S. oil and **78 percent** of gas came from unconventional sources, compared to just 8 percent and 21 percent **globally**. Between 2012 and 2015, average drilling and completion costs in five major U.S. shale plays fell by 25 to 30 percent; since then, rapid **efficiency gains** have driven growth even as rig count **declined**. The scale and efficiency of U.S. unconventional production reflects not only a technical lead but also process expertise. Techniques such as multistage fracturing, pad drilling, and proppant optimization are being successfully adapted to next-generation geothermal, delivering comparable gains in performance and cost reduction.

Table 5: Transferability Between Oil and Gas and Next-Generation Geothermal

	Exploration, Evaluation, and Planning	Drilling, Stimulation, and Well Completion	Surface Facilities, Power Plant, and Transmission
Transferable Technologies and Processes			
	• Surface and downhole sensor technologies • Geological and surface studies • Geochemical and geophysical surveys • Reservoir modeling • Wellbore measuring, pressure testing, and fluid sampling	• Subsurface technologies (drill, motors, control systems, etc.) • Directional drilling and fluid injection • Fracturing and stimulation processes • Fluid and well pressure management • Casing installation • Well design and development • Downhole data collection	• Steam cycle equipment (pumps, well pads, heat exchangers, separators, pipelines, fluid-handling, turbines, cooling systems, etc.) • Well monitoring, maintenance, and periodic injection
Investment Overlap			
Conventional	12%	40%	48%
EGS	12%	57%	31%
AGS	7%	65%	29%

Source: IEA.

U.S. geothermal firms also benefit from a large, adaptable labor force. About 60 percent of U.S. oil and gas workers **possess** skills transferable to geothermal with adequate retraining. Leading U.S.

next-generation geothermal firms have drawn nearly all of their engineering talent from the sector, integrating oil and gas workers with little friction or delay thus far. The size of the qualified workforce is estimated to be nearly 80 percent larger than what full-scale geothermal deployment would require. If employment in fossil fuel extraction continues to **fall**, excess labor could be redirected toward geothermal with the right market mechanisms and policy signals.

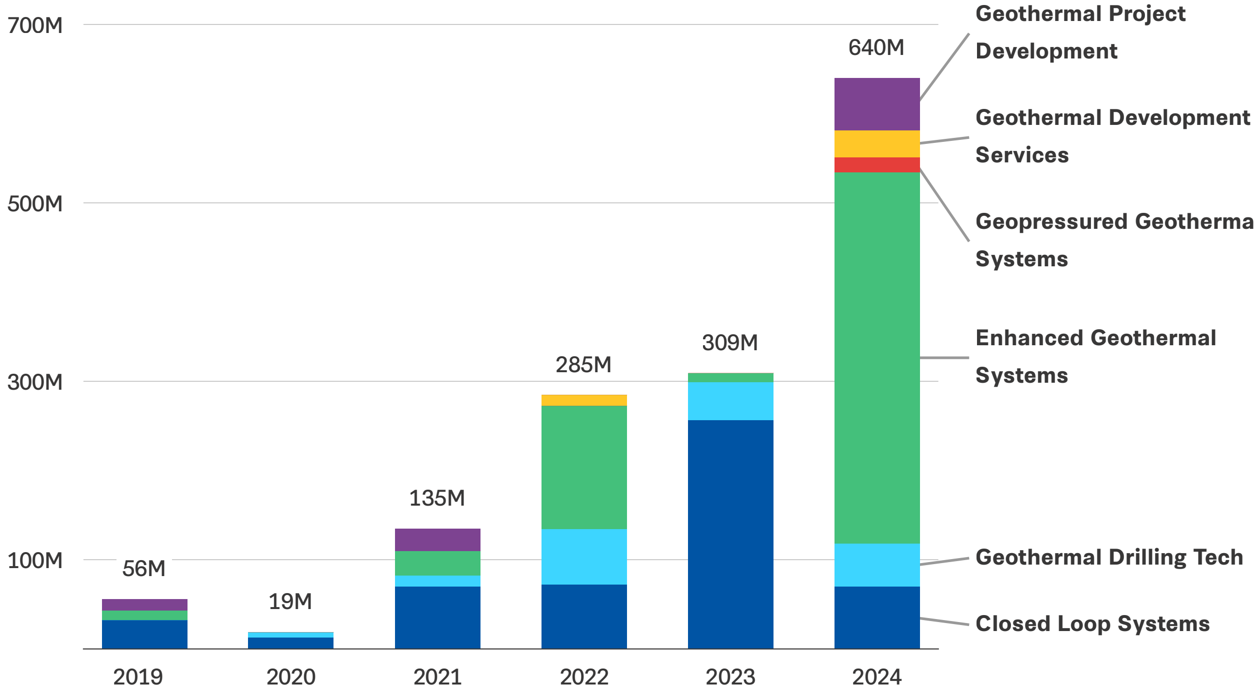
Further, U.S. oil and gas incumbents could be well positioned to accelerate next-generation geothermal development. As it attempts to scale, the sector could benefit from a robust **ecosystem** of both full-service development and specialized engineering, procurement, and construction (EPC) firms with global reach and geothermal-relevant experience. These industry leaders bring decades of subsurface expertise, technical integration capacity, and scalable project delivery. Halliburton's well construction **support** for the Cape Station project, for instance, demonstrates the value of partnerships with mature oilfield service providers in boosting geothermal project development. In addition to technical capabilities, oil and gas incumbents also bring transferable operational and financing expertise in areas such as managing political risk in complex international markets.

Enablers

Geothermal is technically demanding and capital intensive; at the same time, private capital investment committees typically require unlevered rates of return of 15 to 20 percent on projects. As such, access to capital is a key prerequisite of scaling up next-generation geothermal deployment. The United States has demonstrated an ability to mobilize capital at scale due to deep private markets, demand drivers that anchor and de-risk projects, and innovative market mechanisms that help make next-generation projects bankable.

A robust venture capital ecosystem has contributed to the U.S. edge in early-stage financing for next-generation geothermal. Globally, next-generation geothermal has received nearly $2 billion since 2019, with nearly half of the total raised in 2024 alone. Nine of the top fifteen firms to receive funding are **based** in the United States. Fervo alone was responsible for about 40 percent of all capital raised; its early deployments have also demonstrated ways for developers to raise nondilutive debt financing.

Figure 8: Venture Capital and Growth Equity Investments in Geothermal

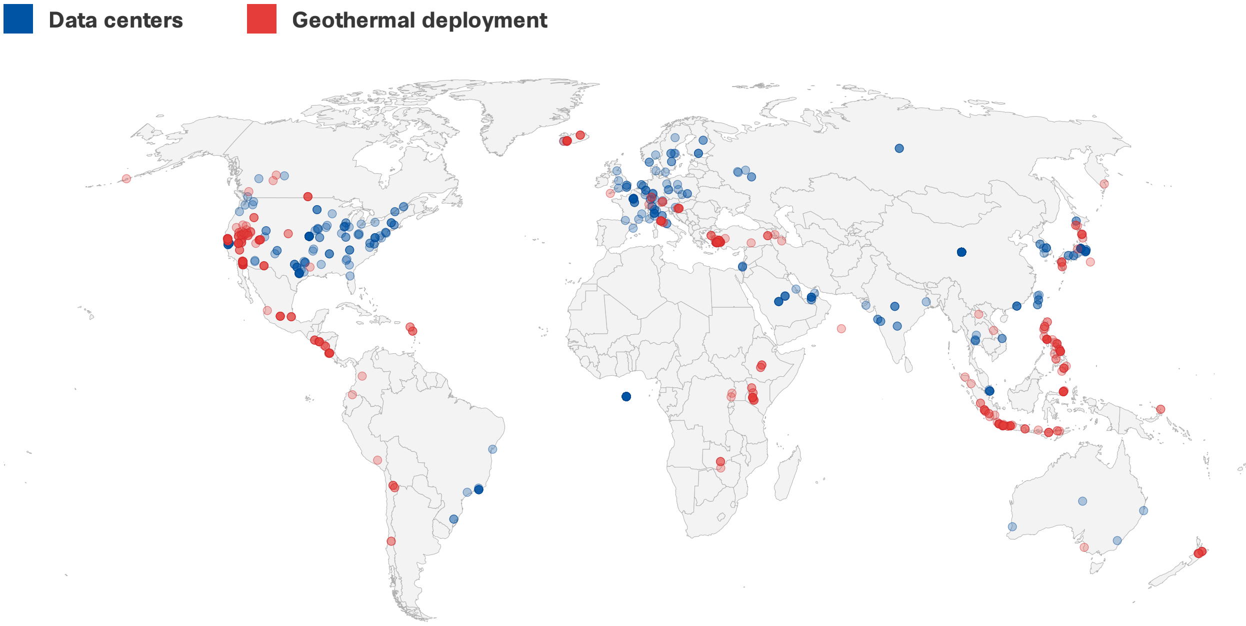


Note: Excludes deals larger than $350 million.

Source: Cleantech Group.

Well-capitalized and geographically expansive U.S. offtakers are emerging as crucial partners for next-generation geothermal. Major technology companies, for instance, are **turning** to geothermal to meet escalating power demands and ambitious decarbonization goals. This has enabled U.S. project developers to **lead** the world in power purchase agreements (PPAs) by both volume and scale. Similarly, the U.S. Department of Defense has **pre-approved** 11 companies to develop geothermal at military installations. These offtakers play a catalytic role in de-risking and unlocking capital for next-generation geothermal, as their procurement commitments both anchor project finance structures and signal overall confidence in the sector.

Figure 9: Map Overlay of Data Centers and Geothermal Deployment



Source: Global Energy Monitor, Epoch AI; author's analysis.

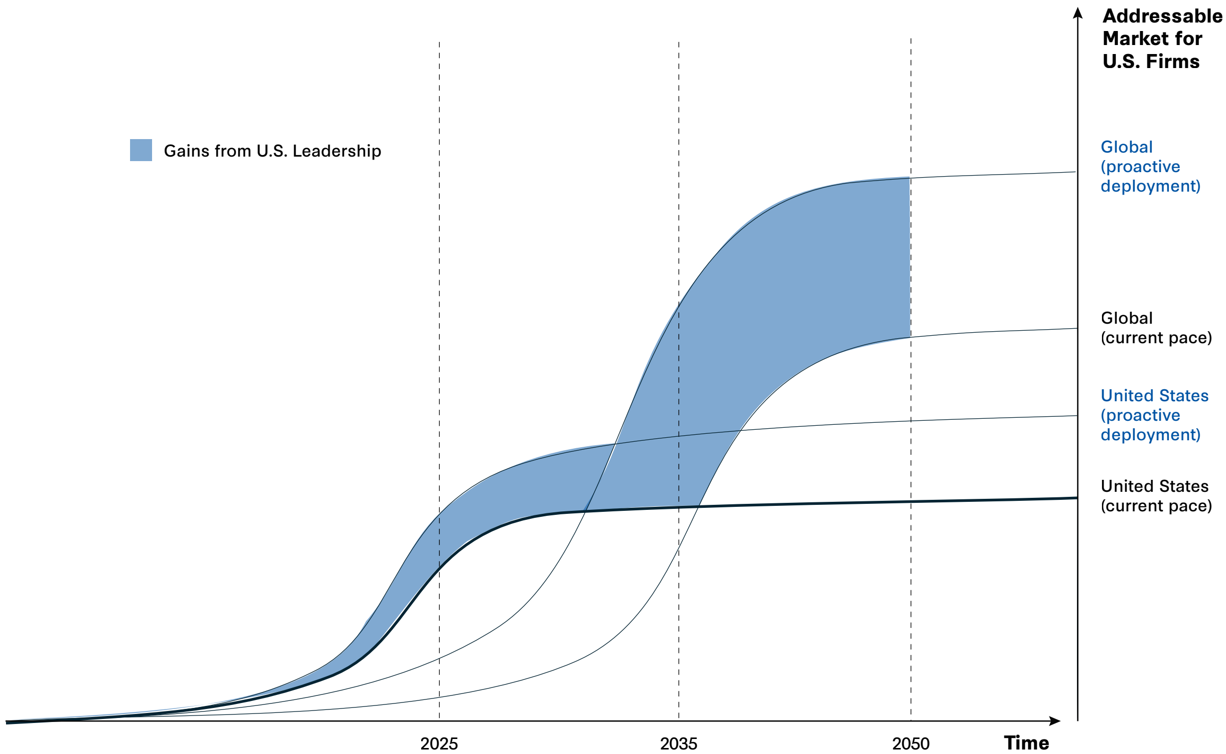
U.S. stakeholders also pioneered innovative market mechanisms that enable further capital inflow into geothermal. The **Clean Transition Tariff** (CTT) in Nevada is a leading example. Developed by Google in partnership with utility NV Energy, the CTT allows the end user (Google) to pay a premium rate to NV Energy, enabling the utility to sign a separate long-term procurement agreement with the geothermal developer. This model protects customer affordability by covering high capital and grid upgrade costs and offers an alternative to traditional PPAs, which often are not suitable for large, capital-intensive baseload power projects like next-generation geothermal. Similar **innovations** including the Centralized Power Procurement Policy in California, group PPAs, and public warehousing facilities could further advance the financial architecture needed to scale geothermal.

Policy Recommendations: Fostering U.S. Leadership

SCALING DOMESTIC AND INTERNATIONAL DEPLOYMENT IN TANDEM

With early commercial deployments gathering steam, next-generation geothermal is at a potential **inflection point**. The United States should actively facilitate its concurrent deployment at home and abroad. Such a bifocal strategy would be crucial to helping U.S. stakeholders maintain their first-mover advantage while expanding next-generation geothermal energy's potential to generate technological, commercial, and geostrategic gains.

Figure 10: Proactive U.S. Leadership Can Accelerate U.S. Capture of Global Market Share



Note: For illustrative purposes only.

Source: Author's analysis.

Next-generation geothermal is currently in the steep phase of its learning curve. Expanding deployment across varied geologies, regulatory environments, financial ecosystems, and grid contexts could yield faster iteration cycles, drive cascading cost reductions, and refine scalable models. From an opportunity cost perspective, the learning potential of next-generation geothermal allows it to deliver high compound benefits–potentially outpacing the incremental improvements expected from mature technologies with the same level of investment.

Proactive global deployment allows the United States to shape the emerging market architecture of next-generation geothermal. First movers often play a defining role in establishing technical standards, regulatory precedents, financial expectations, and strategic relationships. Early and consistent presence abroad embeds durable U.S. leadership into the foundational structure of the global geothermal industry and market, ensuring that its strategic interests are represented.

In addition, scaling next-generation geothermal development abroad enables the United States to lead the formation of a cross-border value chain and innovation ecosystem. The global scale-up of the industry drives innovation spillovers across sectors, stimulates downstream manufacturing and services, and fosters downstream commercial relationships. These linkages reinforce U.S. leadership while delivering economic benefits to countries engaged in the value chain.

To facilitate the global deployment of next-generation geothermal, the United States should pursue both sector-level engagement that enables resilient long-term market growth as well as targeted pilot projects that deliver tangible near-term deployment gains. Executing this strategy will require a coordinated, whole-of-government approach that draws on **historical precedents** to mobilize suitable capabilities across key U.S. institutions. These include the Development Finance Corporation (DFC), Export-Import Bank (EXIM), U.S. Trade and Development Agency (USTDA), Millennium Challenge Corporation (MCC), and relevant bureaus within the Departments of Energy, State, and Commerce.

Table 6: U.S. International Finance Institutions and Capabilities

Instrument	**Product**	**U.S. Institutions**							
		Department of State	*Department of Commerce*	*Department of Energy*	*U.S. Trade and Development Agency*	*Agency for International Development (USAID)*	*Millennium Chllenge Coroportation*	*Development Finance Corportation*	*Export Import Bank*
Engagement	Commercial diplomacy	✓	✓		✓		✓		
Grants	Technical assistance			✓	✓	✓	✓	✓	
	Feasibility studies			✓	✓	✓	✓	✓	
	Training			✓	✓	✓	✓	✓	
	On-lending								
Equity	Equity investments							✓	
	Project finance							✓	
	Capitalization of investment funds							✓	
	Investment consulting services								
Loans	Concessional loans								
	Regular loans							✓	✓
	Resource-financed loans								
	Export buyer's credit								✓
	Preferential export buyer's credit								
	Export seller's credit								✓
	Bond issuance trading								

Instrument	Product	U.S. Institutions							
		Department of State	*Department of Commerce*	*Department of Energy*	*U.S. Trade and Development Agency*	*Agency for International Development (USAID)*	*Millennium Chllenge Coroportation*	*Development Finance Corportation*	*Export Import Bank*
Guarantees	Lease financing and guarantees								✓
	Trade guarantees								
	Loan guarantees					✓		✓	✓
Insurance, securitization, other products	asset-backed securitization								
	Foreign currency settlement								
	Political risk insurance							✓	
	Export credit insurance								✓

Source: Author's analysis.

SECTOR-LEVEL ENGAGEMENT: LAYING THE GLOBAL FOUNDATION

Scaling next-generation geothermal energy globally will require institutional, technical, and market ecosystems that allow the industry to grow in diverse contexts. Sector-level support is essential to create these enabling conditions for long-term deployment, particularly in countries with limited capacity. By leveraging institutions including the MCC and USTDA, the United States can **lead** this groundwork-building effort through both multilateral and bilateral engagements.

Table 7: Conditions for Successful Next-Generation Geothermal Deployment

Technical ability
Physical capacity
Human capital
Operational excellence
Capital access
Public acceptance
Institutional capacity
Policy support
Regulatory clarity
Infrastructure access
Market feasibility
Demand drivers

Capacity Building

The high cost and uncertainty associated with resource characterization remain major barriers to market development. Through knowledge sharing and technical cooperation, U.S. agencies and firms can help equip partner countries to identify and assess geothermal resources. U.S. efforts like the FORGE program and legacy resource mapping initiatives offer valuable templates for **international collaboration**. By adapting these tools and data platforms for international contexts, U.S. experts can help partner countries acquire the capabilities necessary to identify resource potential, map market dynamics, and evaluate domestic capacity.

Fostering local technical capabilities and human capital will be essential for long-term market development. The United States can partner with universities, research institutes, and vocational programs to provide technical assistance and workforce training. These efforts can help **cultivate** a skilled workforce in partner countries that complements, rather than competes with, U.S. firms.

Similarly, industrial and institutional infrastructure will need to be developed to meet the manufacturing, transportation, installation, interconnection, and maintenance needs of geothermal projects. Proactive U.S. leadership in capacity building can accelerate the creation of these value chains while favorably **positioning** U.S. companies. In doing so, the United States can expand its global market footprint, foster strategic interdependence, and embed long-term economic alignment with partner countries.

Enabling Legal and Market Structures

Many countries still regulate geothermal under legacy mining, water, or oil and gas laws; the resulting uncertainties and inefficiencies have led to reduced activity. The United States could integrate **support** for regulatory reform and institutional capacity-building into its diplomatic engagement and assist partner governments in creating geothermal-specific regulatory pathways that cover crucial functions such as risk evaluation and allocation, project tendering process, and licensing. U.S. international finance institutions (IFIs) can further reinforce these efforts by linking financial support to regulatory improvements.

Furthermore, many partner countries lack adequate market tools to support baseload resources. The United States could **promote** power market designs that account for the full value of geothermal energy's reliability, flexibility, and low emissions to facilitate its grid integration. This includes incorporating priority dispatch, capacity markets, or innovative mechanisms like the CTT catered to next-generation geothermal's value proposition and cost dynamics. Similarly, U.S. stakeholders can assist with grid resilience assessments and other measures to inform transmission planning and buildout.

The United States can also lead efforts to align international standards around geothermal components and project design. Promoting modular, interoperable design for key equipment can accelerate procurement and enable manufacturing at scale. By shaping these standards early, favorable technical and procurement standards can be embedded across global geothermal supply chains, giving U.S. firms a strategic foothold as the international market expands.

Securing Social License and Facilitating Demand

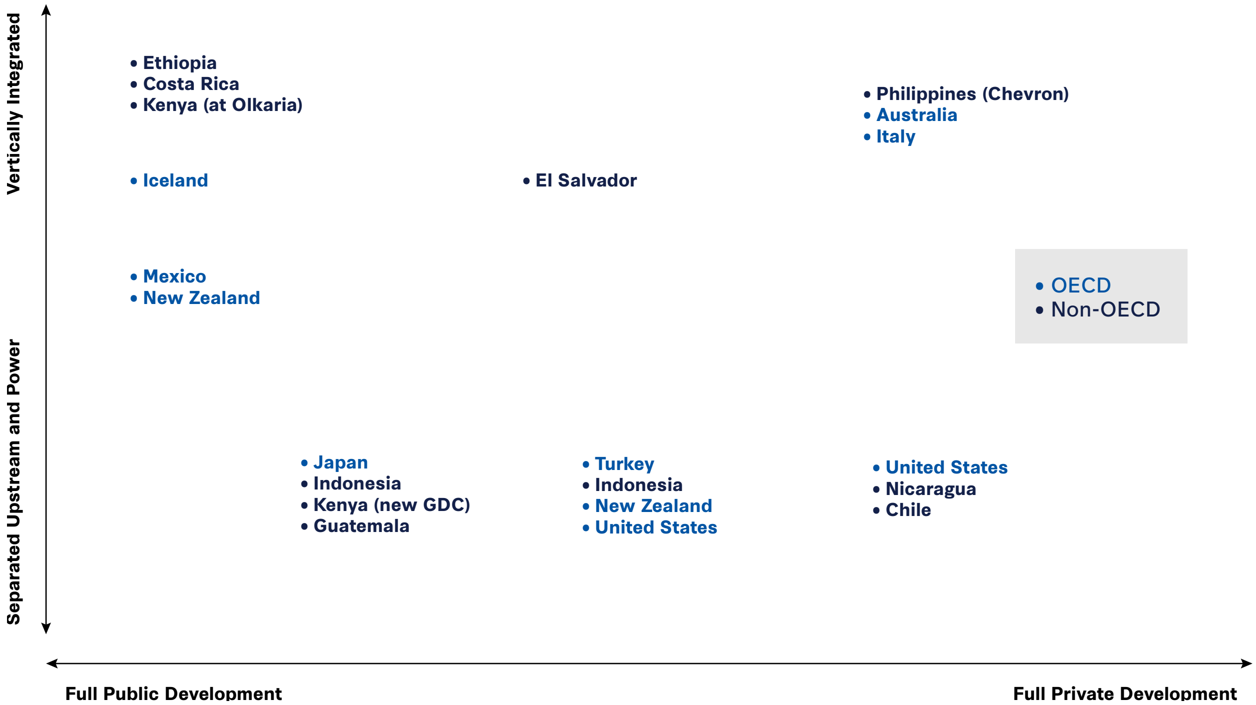
With **concerns** over seismicity, water use, and surface disruption, the risk profile of geothermal energy is sometimes misunderstood by the public and policymakers. To overcome this, the United States could collaborate with local partners to build public support through educational outreach, transparent risk assessment and review, local benefit-sharing mechanisms, and other community engagement that demystifies geothermal and directly addresses concerns. Similarly, reframing geothermal as a strategic national asset that supports economic development, energy security, and climate resilience to local policymakers would be equally important.

The United States can help partner countries unlock demand for geothermal by leveraging its policy learnings, market innovations, and commercial partnerships. By providing technical assistance and advisory support, the United States can help partner governments **create demand signals** through policy tools such as renewable energy portfolio standards with firm power quotas, feed-in tariffs, preferential pricing, tax exemptions, tradable certificates, and procurement mandates. Additionally, the United States can play a matchmaking role by connecting offtakers—such as major tech firms seeking clean baseload energy—with potential global markets.

Strategic Engagement

While countries with significant geothermal deployment have accumulated extensive technical, regulatory, and financial experience, localized institutional and political economy dynamics could introduce **complexities**. Some countries, for instance, have centralized agencies spearheading geothermal development, while others have more regionalized structures. Rather than applying a one-size-fits-all approach, U.S. engagement should begin with a grounded assessment of these contextual variables to ensure its approach aligns with target market conditions and leverages existing capabilities.

Figure 11: International Geothermal Project Development Models



Note: GDC refers to Geothermal Development Company.

Source: World Bank.

PROJECT-LEVEL ENGAGEMENT: ADVANCING STRATEGIC PILOT PROJECTS ABROAD

While sector-level engagement lays the foundation for long-term growth, targeted support for individual project deployment is equally important and represents a high-leverage intervention point for the United States. With comparative strengths across the value chain, the United States is uniquely positioned to spearhead pilot projects abroad to validate next-generation geothermal technologies in diverse geologic and market contexts. These pilots should:

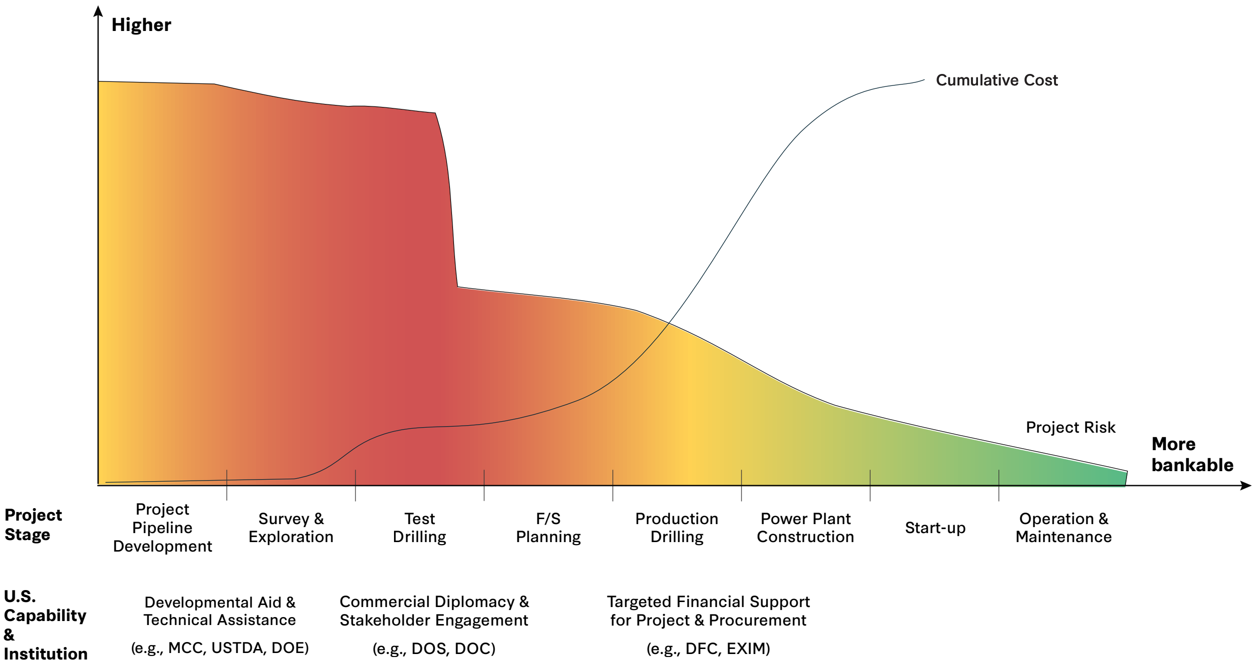
- Showcase technologies, business models, and benefits
- Anchor local workforce and capacity building
- Foster regulatory and policy improvements
- Facilitate strategic partnerships

If these pilot projects succeed, they will add to the successful list of proof points that private investors and industry players need to see to deploy capital at scale. At the same time, they would help U.S. stakeholders develop and sharpen robust, end-to-end project delivery models that strengthen their ability to compete internationally.

Leveraging U.S. Capabilities Across the Project Lifecycle

To effectively support geothermal pilots abroad, U.S. government institutions can take on two key roles: a coordinator of key stakeholders and an underwriter of project financial risks. The United States should deploy its relevant capabilities (see Table 8) in a complementary, fit-for-purpose approach calibrated to the needs and risks of each project stage, as well as market characteristics and broader U.S. strategic interests.

Figure 12: Geothermal Project Development Lifecycle



Source: World Bank; author's analysis.

U.S. commercial diplomacy can play a catalytic role in initiating project pipeline formation by connecting U.S. offtakers, product suppliers, and service providers with investors, host governments, and local stakeholders. Existing bilateral **cooperation agreements** and public-private coordination platforms provide useful templates for relevant U.S. institutions including the Department of State, Department of Commerce, and USTDA. Namely, the United States can consider embedding next-generation geothermal as a strategic component of its broader energy, infrastructure, and technology commercial diplomacy agenda. Efforts to **scale** the global reach of the U.S. AI industry, for instance, provides one such opportunity for synergies.

Table 8: Potential Technical Assistance Activities

Reconnaissance and preliminary exploration
Advanced exploration: geophysics, detailed mapping, geochemistry
Site selection
Drilling, engineering, and management
Well logging
Well testing
Resource assessment
Environmental assessment, impact, and monitoring
Contract development and administration
Reservoir monitoring, management, and quality control
Technology transfer and capacity building

Source: World Bank.

Building on the foundation of sector-level engagement and capacity building, U.S. institutions with technical assistance capabilities can lead in identifying and advancing priority project sites by providing funding, risk-sharing, in-kind support, or insurance mechanisms for feasibility studies and resource characterization. Once project concepts are validated and partnership formation is underway, U.S. IFIs can step in with targeted financial instruments–such as loan guarantees, political risk insurance, or hedging contracts–to mitigate risk and unlock capital from private investors. The DFC, for instance, can provide flexible concessional financing for drilling, wellfield development, power plant construction, and infrastructure buildout. In parallel, EXIM can be leveraged to support the procurement of U.S. products and services for the project through mechanisms such as export credits. Used in tandem, these instruments can not only improve project bankability, but also reinforce U.S. value chain positioning.

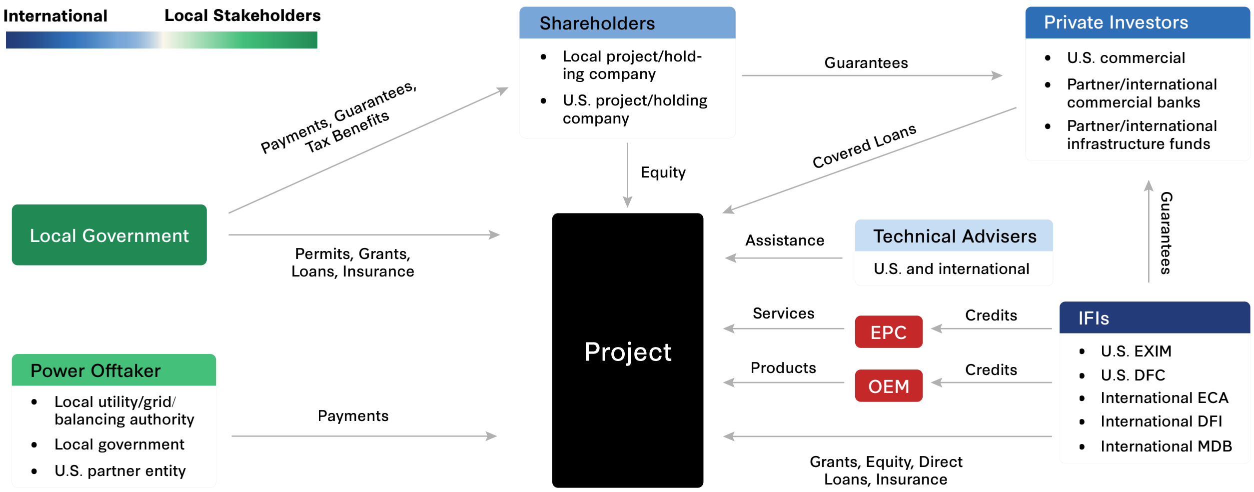
Table 9: Financing Options for Different Stages of a Geothermal Project

Stage Risk	**Early Stage** *High*	**Middle Stage** *Medium*	**Late Stage** *Low*
	▪ Surface exploration ▪ Test drilling	▪ Resource confirmation ▪ Field development ▪ Production drilling and well completion	▪ Power plant engineering, construction, and interconnection
Typical Financing Instruments	▪ Balance sheet financing ▪ Private equity/ venture capital at the company level ▪ Government funding (cost sharing, grants, loans, or guarantees) ▪ Concessional funding (IFIs)	▪ Balance sheet financing, corporate debt or bonds issuance ▪ Public equity issuance ▪ Short-term construction debt ▪ Long-term debt or guarantees (IFIs) ▪ Loan guarantees (partner government) ▪ Export credit ▪ Political risk (civil unrest, expropriation, or currency) and other insurance	▪ Construction debt ▪ Long-term commercial debt ▪ Long-term debt (IFIs) ▪ Partial risk or credit guarantees ▪ Export credit
Potential Provider	▪ Partner government ▪ Project company ▪ IFIs ▪ Private investor ▪ Donor	▪ Partner government ▪ Project company ▪ IFIs ▪ Export credit agency	▪ Partner government ▪ Project company ▪ IFIs ▪ Export credit agency ▪ Commercial bank ▪ Institutional investors

Source: World Bank; author's analysis.

To amplify impact and scalability, the United States should collaborate with relevant government agencies, utilities, and capital providers in partner countries and leverage existing local capabilities. Where possible, U.S. policymakers also should engage multilateral development banks and other development finance institutions. In addition to existing relationships with host governments and investor networks, these institutions offer de-risking instruments and concessional capital that could be complementary to U.S.-led bilateral efforts. For instance, the Energy Sector Management Assistance Program, the Clean Technology Fund, and the Global Environment Facility of the **World Bank Group** have all previously supported geothermal development.

Figure 13: Potential Project Structure



Source: Author's analysis.

Conclusion: Seizing the Opportunity

From nuclear breakthroughs to the shale revolution, U.S. energy innovation has made immense contributions to global technological progress while fueling economic development. With global competitors surpassing the United States in the commercialization, deployment, and refinement of many of the technologies it first pioneered, however, history also **illustrates** that technology leadership must be consistently nurtured with deliberate stewardship.

In an evolving global energy landscape defined by rising demand and growing security concerns, next-generation geothermal represents a unique strategic opportunity for the United States. With comparative advantages across the value chain, the United States is well-positioned to capture commercial benefits, advance diplomatic interests, and solidify its innovation leadership if next-generation geothermal succeeds at a global scale.

Next-generation geothermal energy appears to be at a developmental inflection point, but substantial technological and cost barriers still need to be overcome before widespread commercial deployment is feasible. To capitalize on the United States' first-mover advantage, policymakers should adopt a proactive, deliberate strategy to facilitate the U.S.-led deployment of next-generation geothermal energy at home and abroad.

At the same time, it is equally crucial that next-generation geothermal is integrated into a coherent, whole-of-government approach to advancing U.S. energy innovation. Contextualizing next-generation geothermal within the full spectrum of available technologies will be critical to ensuring that resources are effectively allocated to optimize for overall U.S. energy competitiveness and leadership. ■

Ray Cai *is an associate fellow in the Energy Security and Climate Change Program at the Center for Strategic and International Studies in Washington, D.C.* ***Rebecca Riess*** *is a former intern with the CSIS Energy Security and Climate Change Program.*

The authors would like to thank Charles Gertler, Advait Arun, Leslie Abrahams, Christopher Yu, James Guidera, Annick Adjei, Kate Adie, Zoe Sulmont, and Anthony DeOrsey for providing feedback and data for this report. The authors are also grateful to the individuals who shared their expertise and perspectives–through workshops and interviews–for research that underlines this report.

This report is made possible by the generous support of ClimateWorks Foundation.