

Britain's Buried Power: The Case for Next-Generation Geothermal

✦ britishprogress.org/uk-day-one/britains-buried-power-the-case-for-next-generation

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Summary

- The UK's climate goals demand a substantial increase in clean and firm power and decarbonised heat. Next-generation geothermal energy emerges as a promising yet often overlooked solution to this challenge. Recent advancements have expanded its potential, creating many opportunities in the UK.
- Next-generation geothermal power offers multiple advantages: it is clean, has a small surface footprint, can be built rapidly, offers always-available power, load-following capabilities, and can scale from single MW installations to dozens of GWs across a grid. Because it is constructed by the existing oil and gas drilling workforce, it can be scaled up without building new factories or creating new supply chains. In addition to clean electricity and heat, it produces hot water as a byproduct, which is ideal for district heating networks.
- Next-Generation geothermal plants could revitalise the South-West, North-East, and Northern Ireland, providing high-skilled jobs, affordable electricity, and nearly free heating to areas that need support. These plants could also supply decarbonised heat to local industrial facilities.
- This is a rapidly-developing field with few clear global leaders. The UK was among the first countries to experiment with enhanced geothermal energy in the 1970s. A concentrated push from the government now could result in reclaiming Britain's early dominance and being a global leader for this field. Traditional technical challenges and questions concerning geothermal have largely been solved by government-backed research in the US and Iceland. Relying on this research drastically decreases the financial burden for the UK.
- Current challenges—primarily cost and awareness—can be swiftly addressed through targeted government intervention. **To prioritise next-generation geothermal energy, the UK should:**

- - Raise awareness of geothermal as a renewable firm power and heat solution
 - Unlock specific regulatory and legal bottlenecks that currently obstruct development
 - Make sure geothermal can fully benefit from Contracts for Difference incentive mechanisms
 - Issue a policy statement promoting enhanced geothermal expansion
 - Allocate new funds for active government initiatives to facilitate geothermal development.

Challenge and Opportunity

The Need for Firm Power

The UK faces daunting financial, logistical, and technical hurdles in its quest to decarbonise electricity by 2035 and heat supply by 2050. These ambitious targets require a [175% increase](#) in zero-carbon electricity by 2035. [The UK has decarbonised faster than its peers](#), but as gas and coal power plants are phased out, solar and wind fall short of being a complete solution. To completely decarbonise, the UK needs firm-power solutions that can be scaled up and down on demand.

Solar and wind power, at their peak, provide as much as [64% of UK electricity](#). But, while they are an excellent way to decarbonise much of the grid, they do not provide firm power. A grid overly reliant on intermittent energy sources like solar and wind power can suffer from significant problems. This issue is evident in places like [California](#) and [Germany](#) where, despite having a surplus of energy during the day, at night the [grid can fail to meet peak demand](#) even with fossil fuel backup. Without firm power alternatives counteracting the supply variability from these energy sources, it is estimated we would need to pay a [50-100%](#) cost premium to have a stable grid.

The UK's goals [demand the integration of 'firm-energy'](#) sources—reliable and flexible options that consistently meet demand regardless of weather conditions. Unfortunately, there are no silver bullets for firm energy:

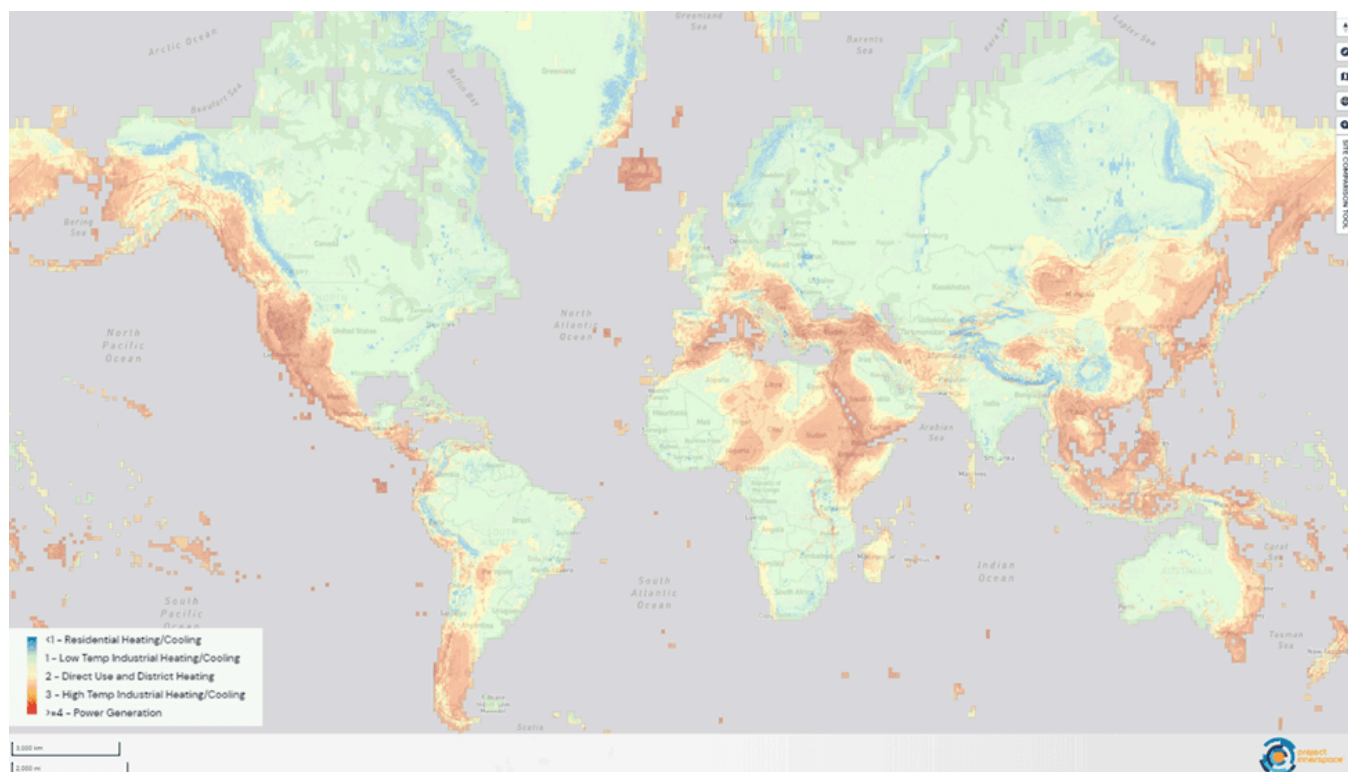
- Large-scale industrial batteries face technological barriers for long-term storage or scalability issues.
- Wave and tidal power, despite their potential to generate [11% of UK power](#), confront numerous technical and environmental obstacles, delaying their market readiness.
- Even nuclear energy, whose [expansion we support](#), grapples with high costs and prolonged construction timelines for new plants.

In this briefing we lay out the case for UK next-generation geothermal power including steps that can be taken to access this abundant source of energy.

The Case for Next-Generation Geothermal Power

Geothermal power harnesses heat from the Earth's crust, converting it into electricity or utilising it directly for heating purposes. Traditionally, geothermal energy exploitation was limited to a few unique geological locations where substantial heat naturally rises to the Earth's surface. For example, in Iceland – an island that hit the thermal jackpot – [70% of total energy comes from geothermal sources](#). However, recent advancements have significantly expanded the potential for geothermal power. These innovations could now enable next-generation geothermal energy production in locations previously deemed unsuitable, including the UK.

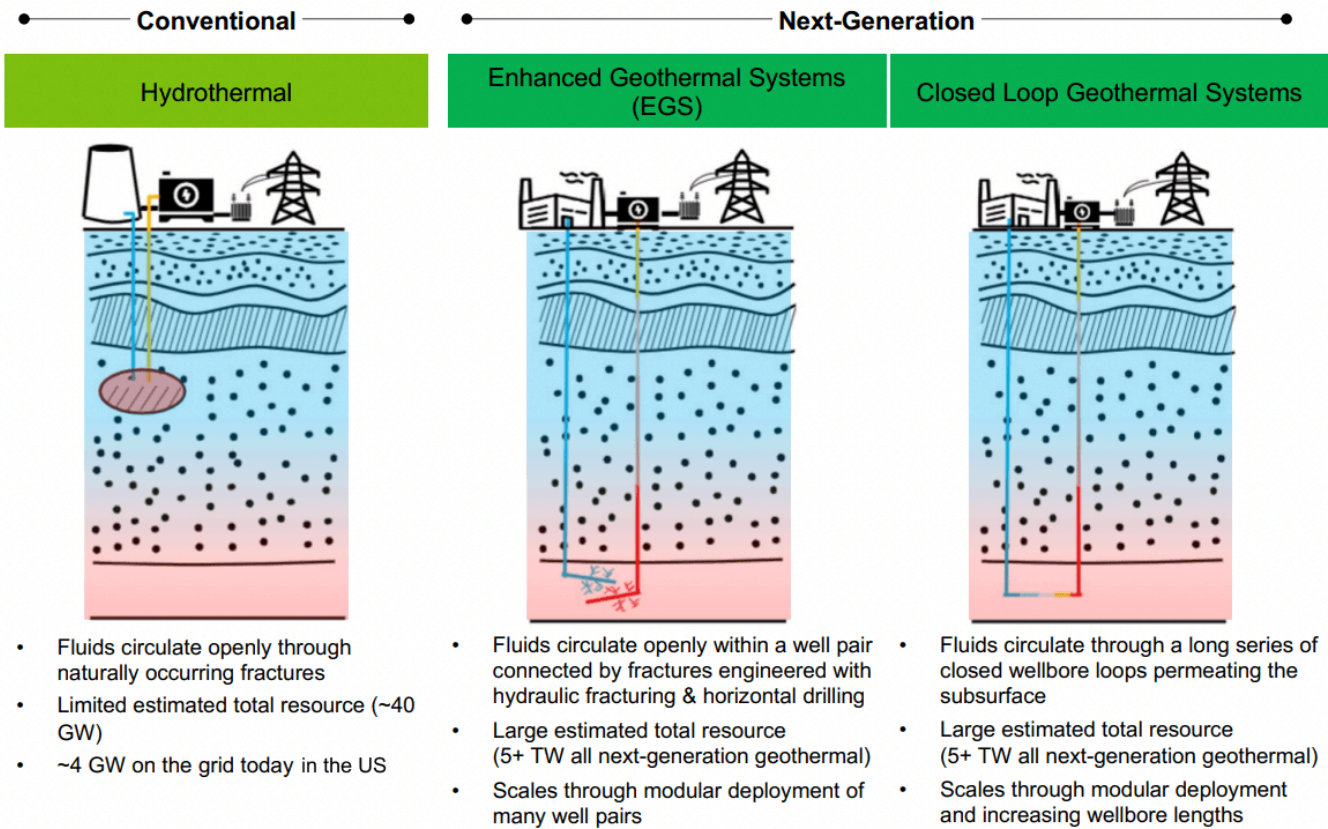
Figure 1: Map highlighting thermally active regions of the world. In general, the darker the red the easier it is to capture geothermal energy.



Source: [Project Innerspace](#)

Geothermal power generation falls into two main categories: conventional (hydrothermal) and next-generation (Figure 2). Conventional resources rely on naturally occurring conditions and are relatively rare. Next-generation technologies, particularly Enhanced Geothermal Systems (EGS), use modern engineering to expand geothermal potential across diverse geological settings. While there are other types of next-generation technologies, this paper focuses mainly on EGS.

Figure 2: Overview of geothermal technology across conventional and next-generation designs



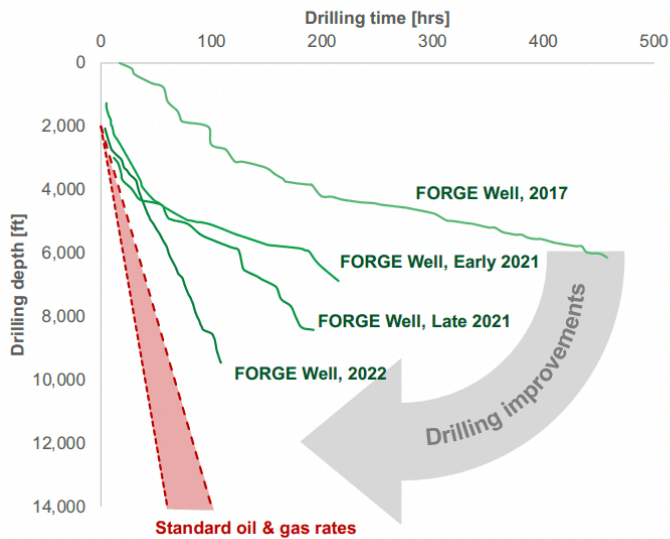
Source: [US Department of Energy](#)

EGS applies directional drilling and hydraulic fracturing techniques developed by the oil & gas industry to create fractures in hot, previously impermeable rock, allowing fluid circulation and heat extraction. These approaches were previously infeasible due to drilling costs, but in the last five years, technology has quickly improved. These advancements have been driven by collaboration between government laboratories and private investment. The DOE-backed Utah FORGE initiative initiated this progress by conducting ground temperature studies and demonstrating potential cost savings in drilling.

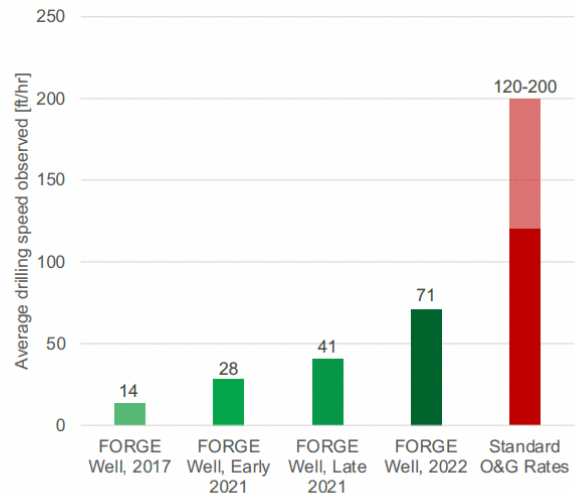
These successes inspired oil and gas entrepreneurs to create new companies to harness this potential, leading to further cost reductions. For example, Fervo Energy in Nevada has drastically cut the time and cost required to set up new EGS wells, cutting overall costs [by almost 50% and drilling times by almost 500%](#). Fervo Energy has [successfully built a commercial project](#) in Nevada and is [now building 400MW more](#).

Figure 3: Drilling rate improvements in early next-generation geothermal demonstrations

Drilling timelines at DOE FORGE demonstration site



Average drilling times at DOE FORGE demonstration site



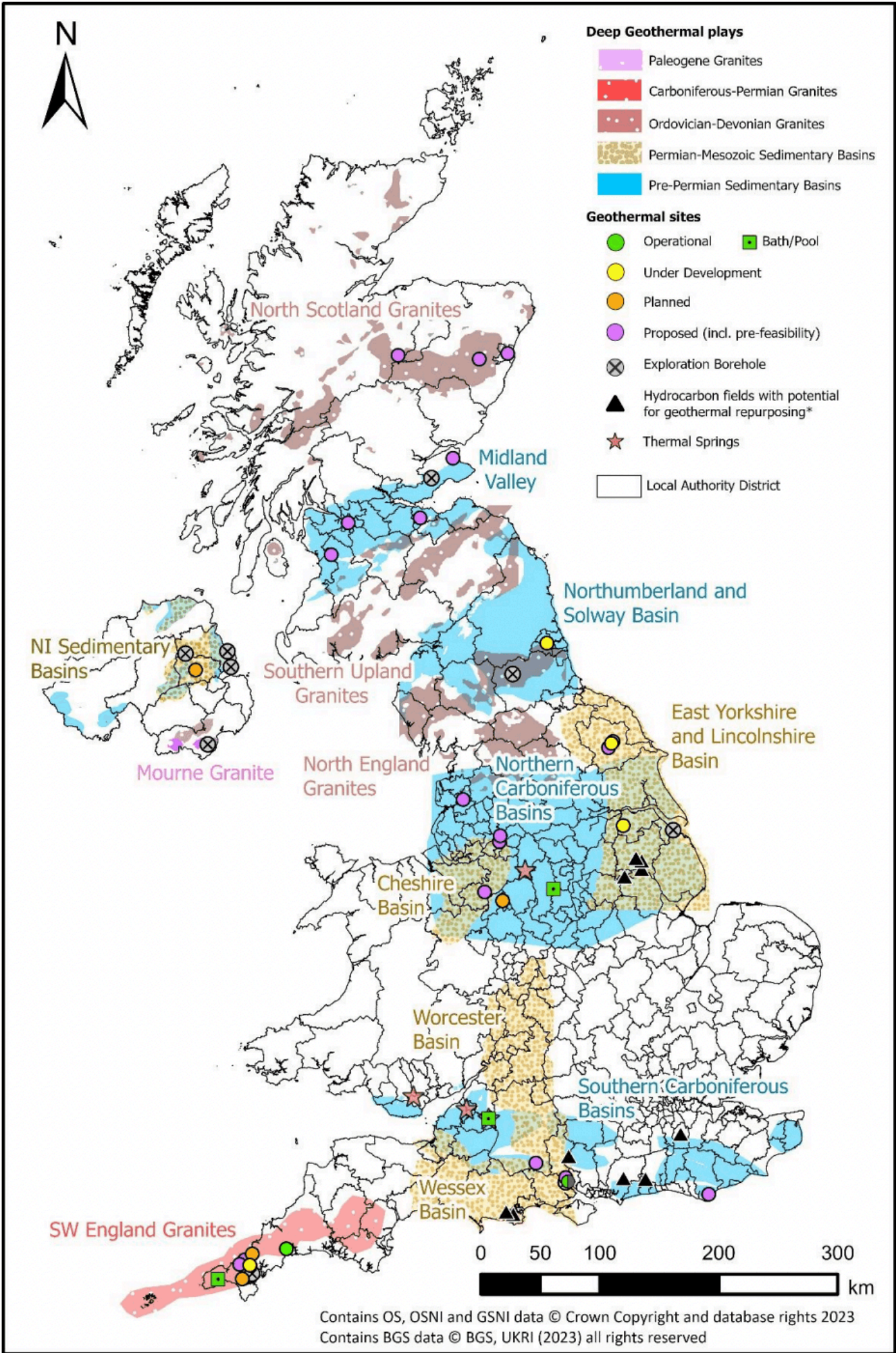
Source: [U.S. Department of Energy](https://www.energy.gov)

Next-Generation Geothermal Can Complement Natural Gas in the UK's Energy Mix

In recent decades, the UK and the world have seen a rapid rise in solar and wind energy. However, this progress has been closely followed by the expansion of natural gas power plants. These plants — inexpensive to construct and primarily costing money when burning fuel — have become the go-to solution for balancing the variability of solar and wind power. They can quickly adjust their output, shutting down when renewable energy is plentiful and ramping up when needed, all while minimising fuel costs. As we move towards a grid powered entirely by clean energy, the main challenge lies in replacing the essential balancing role that gas plants currently provide. Solving this will be crucial to achieving a truly sustainable energy future.

Next-Generation geothermal energy offers a promising solution. The UK boasts a diverse range of geothermal resources, from direct heating applications to power generation. There is extensive potential in various deep sedimentary basins, such as the Worcester, Wessex, Cheshire Basin and East Yorkshire-Lincolnshire Basins, with [ongoing tests](#) in Northern Ireland's Sherwood aquifers in Lough Neagh and Lagan Valley.

Figure 4: Map showing the location of the potential deep geothermal targets across the UK alongside selected onshore hydrocarbon fields (triangles), occurrences of known thermal springs (stars) and geothermal projects at different stages of development from pre-feasibility to operational.



Source: [Open Report OR/23/032](#)

Like natural gas plants, next-generation geothermal plants can rapidly adjust their output, providing the same 'load following' flexibility needed to stabilise the grid. Additionally, EGS plants [can act as a form of energy storage](#) by using excess electricity from the grid to increase pressure in their reservoirs, which can then be tapped into when needed. This dual capability positions next-generation geothermal energy as a powerful tool in the transition to a fully renewable energy grid.

The future of energy in the UK and worldwide will inevitably be a mix of different sources. No single energy source is going to meet all our power needs. This proposal does not suggest geothermal is a panacea. However, there is reason to think next-generation geothermal energy is currently undervalued and underfunded, despite its significant potential as a renewable energy solution.

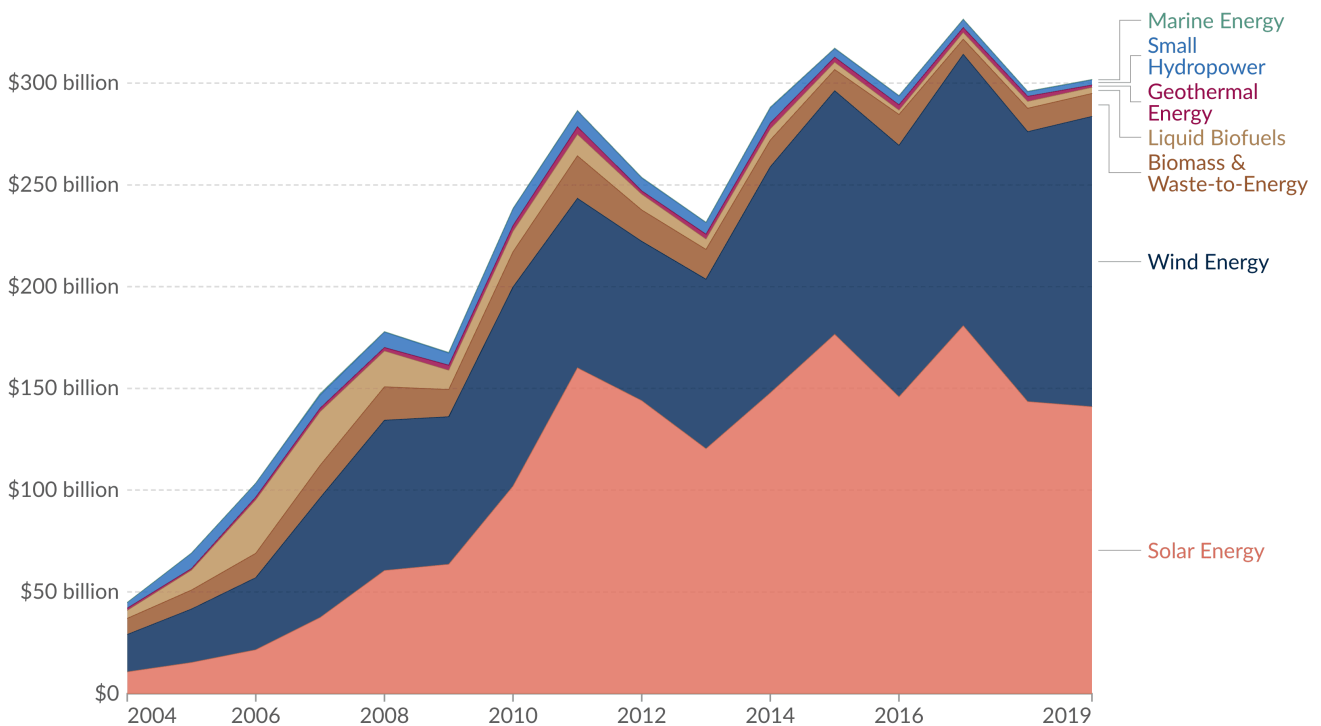
As of 2019, global investment in geothermal energy amounted to approximately \$1.5 billion, making it the least funded of all traditional renewable energy sources despite having great potential for further cost reductions. In comparison, nuclear power received [\\$35 billion in investment](#), while [wind and solar each received more than \\$100 billion](#) during the same period.

Figure 5: Geothermal represents a tiny fraction of investment into renewable energy

Investment in renewable energy, by technology



Global investment in renewable energy technologies, expressed in US dollars not adjusted for inflation.



Data source: Frankfurt School-UNEP Centre/BNEF (2020)

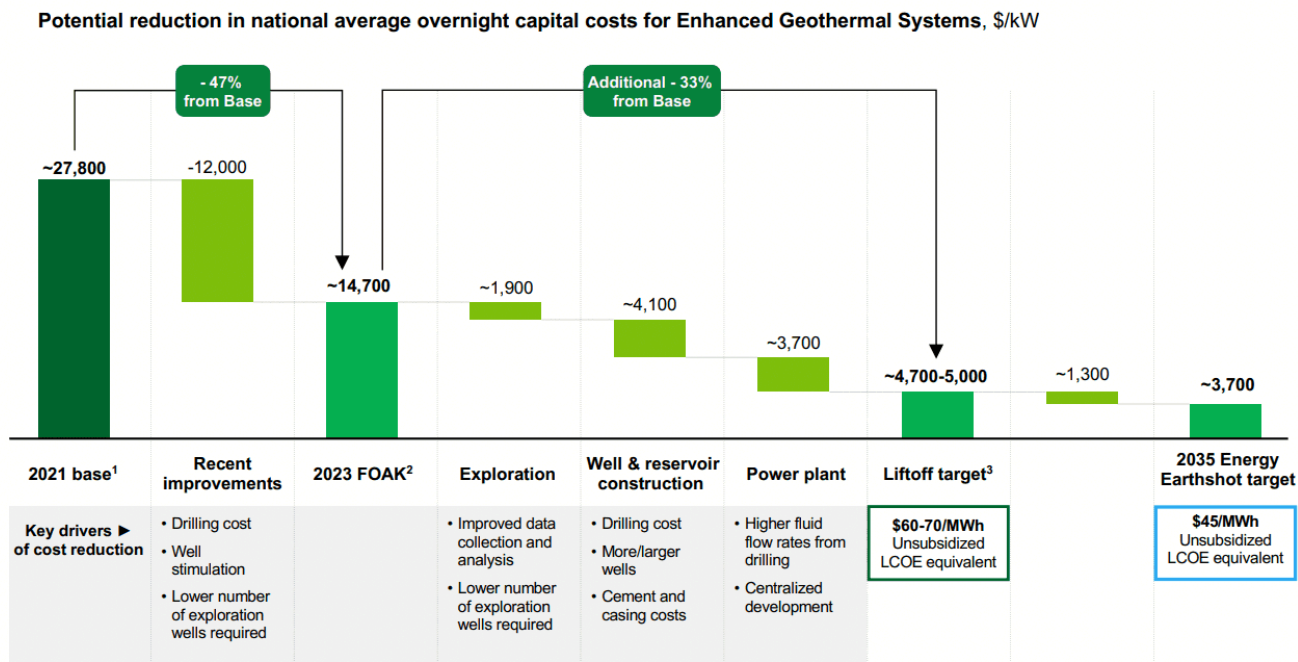
OurWorldInData.org/energy | CC BY

Note: Investment figures exclude large-scale hydropower schemes.

Source: [Our World in Data](#)

Investment in next-generation geothermal could lead to outsized returns: there is significant potential for cost reductions and efficiency improvements. According to the US Department of Energy (DOE), modest investment in next-generation geothermal technology could lead to a 33% reduction in costs over the next decade (Figure 5).

Figure 6: US Department of Energy’s Cost Reduction Estimates

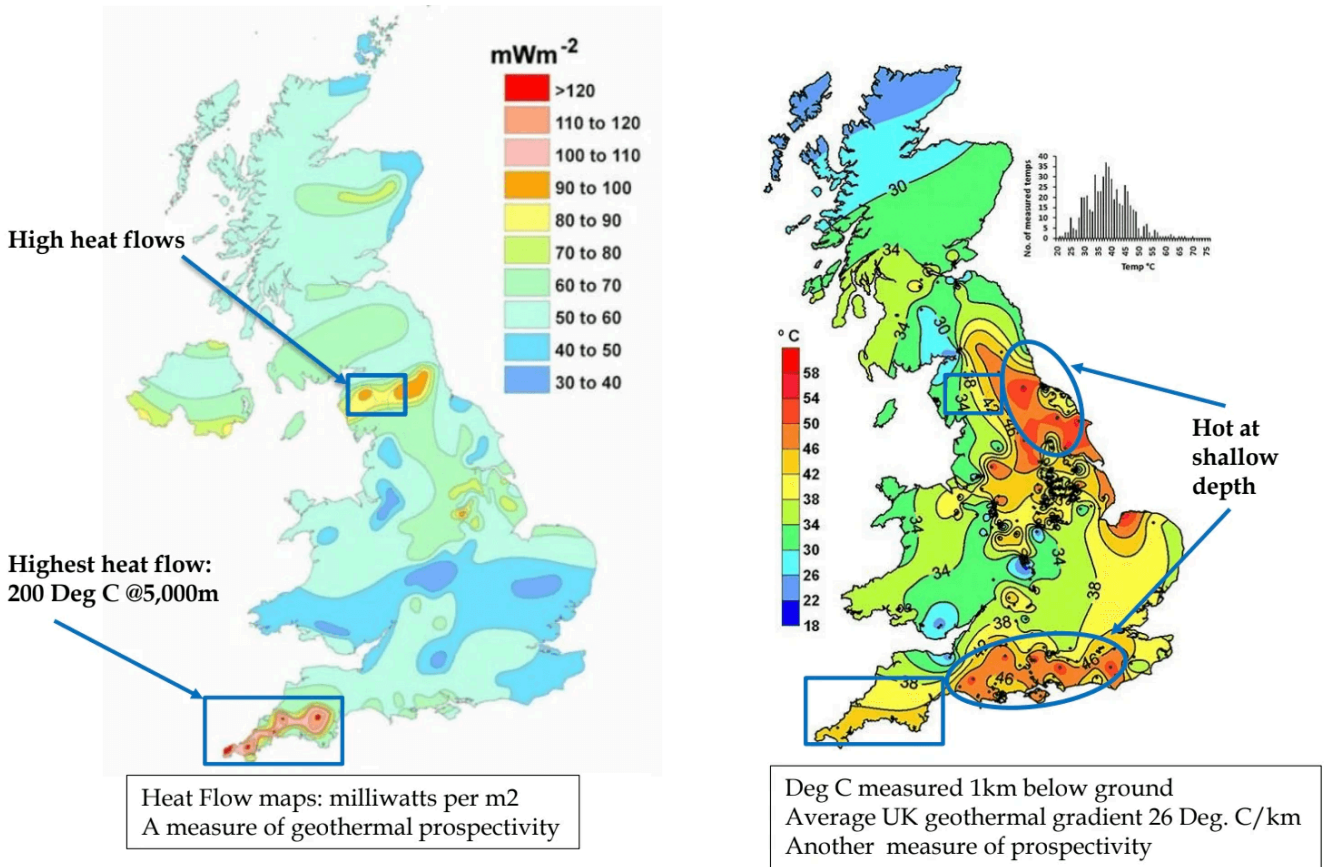


Source: [U.S. Department of Energy](#)

Building out next-generation geothermal in the UK

Hypothetically, next-generation geothermal could produce up to [200%](#) of the UK’s domestic electricity needs and provide substantial amounts of low-cost district heating. Two large hot granite batholiths – the Cornubian and North Pennine – could theoretically power the UK for hundreds of years.

Figure 7: Areas of geothermal opportunity in the UK



Sources: British Geological Survey; European Geologist Journal 43 – Geothermal – The Energy of the Future: Busby & Collins/Scottish Government LCTIP

Source: [J. Busby et. al; 2011](#)

While harnessing all of this energy may be nearly impossible, a significant portion could be accessed. With current technology, about 20% of the UK's energy needs could be provided by next-generation geothermal (which roughly would put it on par with nuclear). This could be accomplished quickly by adopting [pad drilling](#). Pads with 10-20 wells on them can be drilled in rapid succession, yielding economies of scale and iterative cost reduction. By establishing 50 sites with 10 pads each – most sites being clustered in the two hottest regions of the UK, the UK could produce [roughly 18 GW or 150 Terawatt-hours a year](#). This ambitious target is achievable due to the potential speed of installation and [the low aboveground footprint of each site](#).

This scale of geothermal build-out could directly replace over 45% of the UK's current fossil power generation. It also complements and reinforces wind and solar by providing the load-following, storage, peaking, and backup service required to enable solar and wind to fill out the remainder of the grid.

Table 1: Geothermal value proposition

CATEGORY	VALUE PROPOSITION
Environmental	Clean, minimal footprint
Operational	Firm, flexible, no fuel costs
Infrastructure	Rapid development and deployment, low transmission buildout
Economic	Existing workforce from O&G sector, highly local permanent jobs, prime locations in areas designated as levelling up targets
Energy Security	Secure supply chain, domestic power generation

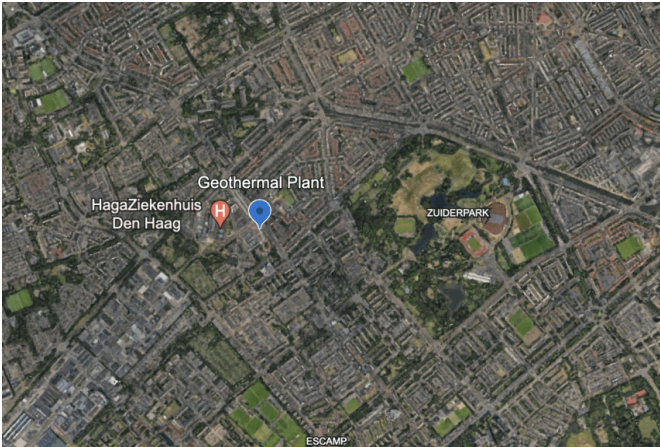
Importantly, next-generation geothermal can be built fast, which makes it helpful for the UK’s 2030 and 2050 net-zero goals. Currently, Fervo Energy can drill a new geothermal well [in as little as 21 days](#). Fervo is the first company to achieve such fast and cost-effective drilling times, but since Fervo's breakthroughs use readily available oil and gas technologies, it is likely that other players will quickly replicate these results. Replicating this efficiency could mean each new site is completed in as little as 3 years.

Geothermal plants also generate large quantities of hot water as a byproduct of electricity production. This could be used to heat homes and buildings in nearby communities or in industrial processes. This heat would be sold very cheaply: likely around 1 p/kWh. For comparison, gas heating costs 7p/kWh and electricity costs 27p/kWh. While this heat would only be available near EGS plants, it still represents massive savings for these communities. This clean heat production would also reduce grid demand and further reduce emissions. In other words, investments in next-generation geothermal power not only help decarbonize the power grid, but also help cost-effectively decarbonize residential and commercial heating and cooling as well as industrial heat.

The most promising EGS sites in the UK – the Cornubian and North Pennine batholiths – are located in areas facing economic difficulties. A report commissioned by the prior government estimated that of the 10 local authorities with lowest economic resilience 6 [are in ideal locations for enhanced geothermal](#). The introduction of next-generation geothermal plants would provide high-paying jobs and incredibly cheap heat, supporting the government’s levelling-up initiative for the southwest and northeast.

Geothermal energy has a lower environmental footprint compared to fossil fuels and even some other renewable sources. It produces no greenhouse gas emissions and can provide base-load and load-following power, which is essential for grid stability. They also do not provide risks to human health so can be built in cities and near residential areas.

Figure 8: Drilling being done in The Hague Netherlands – less than 20 metres from homes and across the road from a hospital.



Finally, while this proposal primarily focuses on EGS, other technologies such as smaller district heating plants and geothermal batteries also show promise. Expanding research and funding into EGS will likely benefit these technologies as well, creating a robust and diversified next-generation geothermal energy sector in the UK.

Constraints to Next-Generation Geothermal in the UK

The UK was once a global leader in EGS, [constructing one of the first test sites at Rosemanowes Quarry in the late 1970s](#). Funded by the DOE and the EU they conducted tests, drilled boreholes, and researched energy output until the early 1990s. But due to high extraction costs and changing energy markets, investment dwindled.

Since the late 1990s, geothermal energy has had almost no presence in the UK. Current geothermal capacity is less than 10 MW. At this juncture, four major roadblocks hinder the expansion of next-generation geothermal energy in the UK:

Awareness

According to [experts and city councils](#), the primary obstacle to the expansion of EGS is a lack of public awareness. Major political parties, including Labour, the Conservatives, the Liberal Democrats, and the Greens, fail to mention geothermal energy on their websites, even though they discuss comparable firm power solutions such as hydrogen, tidal power, and nuclear power. EGS requires trailblazers, bold entrepreneurs, and visionaries to establish a sustainable market for growth. The fact that awareness is perhaps the top obstacle today creates a perfect leadership opportunity for the new government to be that visionary trailblazer.

Financial Risk

Like most clean energy projects, the upfront costs for EGS are substantial and ongoing operating costs are minimal, with drilling and materials accounting for the majority of a plant's lifetime expenses. This is the opposite of the financial profile of fossil power plants, creating a unique challenge for new clean power to get widespread finance. Specific factors making it hard to finance geothermal plants include: Britain's current venture challenges, the relatively long return on investment, the lack of public awareness, concerns about sustained power generation, the novelty of the technology, and a lack of understanding how next-generation geothermal is different from traditional hydrothermal. These obstacles have prevented any UK

geothermal project from initially [receiving private funding](#). Instead, projects in the UK have relied on EU grants or local council funding, the former now inaccessible, and the latter difficult to secure.

In fact at the moment, local councils are even struggling to fund techno-economic analyses (the low-cost precursor analysis needed to demonstrate the viability of geothermal in an area), preventing many from even considering geothermal as an option. **Introducing new government programmes that incentivize techno-economic analyses will be very impactful in supporting early-stage geothermal adoption.**

Currently, there is no central government support for any deep geothermal projects. Even the Contracts for Difference (CfD) program, which was designed to support low-carbon energy alternatives, rarely benefits EGS. This is because CfDs prioritise cheaper, already proven technologies, neglecting to account for the necessity of firm power. **Financial support for geothermal, comparable to that of other clean energy alternatives, is essential for its expansion into the UK and why the new government should ensure next-generation geothermal is eligible for the CfD program.**

Insufficient Data

While EGS does not have resource risk in the way traditional geothermal does, choosing locations for EGS still requires accurate geological data. Operators need to understand the type of rock, the likely heat gradient and temperature at the desired depth, the location of groundwater, and the positions of faults before drilling. Without this information, projects face greater risk, mainly of going over budget due to rock formations being different from expected. Unfortunately, in the UK, the available data is unreliable. Most ground temperature studies were conducted at depths much shallower than those required for EGS. **Without more accurate data, it is improbable that companies or entrepreneurs will take the risk on EGS.**

Limited Know-how

The UK has not seriously explored geothermal energy for more than 20 years, resulting in a scarcity of relevant legislation, regulation, and finance. Additionally, there is limited institutional knowledge, even among academics. Unlike the US, there is a lack of drilling equipment in the UK. Consequently, the UK does not possess the high-speed drilling rigs necessary for making EGS economical. The UK also does not have the equipment needed to stimulate the rocks to create reservoirs. **This equipment is essential for the establishment of EGS in the UK; the UK would need to source this equipment — most likely from the US.**

Plan of Action

To accelerate next-generation geothermal developments in the UK, the government should pursue the following actions:

Minimal Enabling Steps:

1. Publish a Ministerial Statement by the [Secretary of State for Energy Security and Net Zero](#) that expansion of Next-Generation Geothermal energy plants, particularly EGS, could conceivably provide up to 20% of the UK's electricity demands and large amounts of network heating.
2. Extend the definitions of the existing commitment to Contracts for Difference (CFD) and Feed-in Tariffs (FiT) to include heat as well as geothermal electricity.
3. Provide clarity on the right to drill through mineral rights to access heat only where third-party ownership of subsurface mineral rights is severed from surface rights. There are currently legal cases pending on permissions not sought from mineral owners when excavating foundations.
4. Clarify fracking regulations concerning EGS. In particular, examine possible safety concerns specific to next-generation geothermal and make sure those concerns are addressed. Explore possible exemptions next-generation geothermal may enjoy from hydrologic fracking regulations.

Additional Steps:

5. Launch a new Central Government effort to support next-generation geothermal projects with the following provisions:
6.
 1. Provide economic support for Council-led techno-economic assessments for next-generation geothermal energy projects. Currently, Councils must either match-fund partial smaller grants from local taxpayers or seek other grants, which is often time-consuming and unsuccessful. Assuming 15% of the 307 councils conduct a study each year at a hypothetical; cost of £0.5 million per study, the annual cost would only be approximately £25 million.
 2. Provide support for two commercial-scale pilots of even more advanced geothermal drilling techniques to access even deeper rock in the future, expanding EGS's geographic potential to every part of the UK.
6. Create or amend regulations to make it easy for EGS projects to reuse Environmental Impact Assessments that have already been carried out for the same plot of land or for very nearby/equivalent parcels of land.

FAQs

What are the environmental risks of enhanced geothermal systems?

The two primary concerns posed by enhanced geothermal systems are (1) groundwater disruption and wastewater disposal and (2) earthquake risk. Traditional geothermal has been known to have environmental concerns, such as the release of hydrogen sulphide gas, which are not as relevant to EGS. Both of these concerns can and should be adequately addressed through government action.

The most substantiated dangers associated with fracking are its disruption of groundwater and the disposal of wastewater. These issues are likely to be less significant in EGS in the UK for several reasons:

- EGS would be implemented in granite in the UK, rather than shale. Granite does not contain the toxic chemicals found in shale, reducing the likelihood of methane and other harmful chemical leaks.
- EGS involves drilling much deeper than oil and gas production does, which minimises the risk of disturbing groundwater.
- Water use/allocation, a major issue in the US and therefore something that has become a general concern raised around geothermal, is less pressing in the UK due to its wetter climate.

In terms of earthquake risk, recent studies indicate that fears of earthquakes caused by fracking [are exaggerated](#). That is not to say it is completely without risk. A recent review has linked a [magnitude 5.5 earthquake](#) in South Korea that caused 75 million dollars in property damage. This earthquake was the result of drilling on a fault line which can be avoided in the UK.

Much of the ecological damage in the US occurred during the early stages of fracking technology, before effective regulations and safety measures were in place. Over the past decade, this damage has significantly decreased as the industry has matured and implemented better practices. The UK can adopt these proven regulations and safety measures from the US for EGS to mitigate potential environmental risks.

What about Sir David Mackay's criticisms of geothermal? Can geothermal really meet all of our energy needs?

Sir David J. C. MacKay, the former Chief Scientific Advisor of the UK Department of Energy and Climate Change, presented critical views on geothermal energy in his book *Sustainable Energy – Without the Hot Air*. His criticisms are often cited in discussions about the viability of geothermal energy in the UK.

Mackay's first major criticism is that even if the UK were to cover every square centimetre of the country with geothermal energy production, it would only meet about [20% of the country's energy demand](#). This assumption, however, is based on the premise that geothermal energy must avoid the cooling of surrounding rocks. When we extract geothermal energy by heating water to generate electricity, the surrounding rock cools down. Although the Earth's crust contains vast amounts of thermal energy, this energy is relatively static and does not quickly replenish the heat extracted. For EGS to produce a significant amount of energy, we need to cool the rock faster than it can be naturally reheated by surrounding areas.

This cooling process results in the rock's temperature dropping by 1-2.5 degrees Celsius per year. Over a period of 20 years, this would lead to a temperature decrease of more than 50 degrees Celsius, causing the rock to contract by approximately 0.03%. Such a reduction in temperature can render most geothermal wells unviable after 20-30 years. In this case, it is

possible to drill new wells on the same site, which would allow it to stay in operation. To put this in context, hydrothermal already has to regularly drill new wells on the same site to maintain production and there are reasons to think this would have to happen less often for EGS. This is no different than other renewable technologies where solar panels and wind turbines also last about 20-30 years before the equipment needs to be replaced to maintain production.

Mackay's second criticism is that even if heat were mined like a resource, the available energy would still be insufficient. He cites consultants who estimated that the total energy in hot dry rocks is 130,000 TWh, which would provide only 1.1 kWh per day per person for 800 years, or roughly 10% of the UK's electricity. Additionally, these consultants concluded that the "generation of electrical power from hot dry rock was unlikely to be technically or commercially viable in Cornwall, or elsewhere in the UK, in the short or medium term."

This claim warrants closer scrutiny. Firstly 130,000 TWh is a vast amount of energy (the UK consumes in the region of 350TWh of electricity per year), their analysis therefore suggests that the entirety of the UK's electricity needs could be met by geothermal for 100s of years. We are advocating that the UK uses geothermal as a firm-power source to supplement other zero-carbon options (solar, wind) rather than using it to meet 100% of our energy needs.

Furthermore the 1.1 kWh per day per person estimate is based on what consultants deemed conceivable in 1992. More recent surveys suggest significantly higher energy potentials. For instance, some sources claim that the North Pennine Basalt alone could contain [733,000 TWh](#), and the Cornubian an additional [1,472,500 TWh](#). While not all of this energy can be harnessed, tapping into 18 GW remains feasible, and advancements in deeper drilling could further increase the available supply.

Over the past 30 years, many of the technical and economic challenges associated with geothermal energy have been addressed. With appropriate investment, geothermal energy could now be a viable option. All this is not to fully discredit Sir Mackay's warnings. He is correct to claim geothermal will not provide all of our energy, but neither will any other energy source. Furthermore, unless we can dig deeper (which improvements in drilling suggest we can do), the amount of available energy for UK geothermal is indeed limited. What Mackay gets wrong is the scale. As we face the most drastic and consequential energy transformation in our history, we cannot ignore this potential source of clean firm energy.

How expensive is Geothermal?

Estimating the costs for geothermal energy in the UK is challenging due to limited data and uncertainties about future cost reductions. A [recent proposal](#) to construct four 9.5km wells producing 13MWe in Durham is projected to cost \$143 million, resulting in a Levelized Cost of Electricity (LCOE) of £115/MW/hr. This figure is already more competitive than nuclear energy in the UK, where the LCOE for Hinkley Point C ranges between [£150 and £250/MW/hr](#).

In the US, geothermal energy is significantly cheaper, with current LCOE figures between [£50 and £82/MW/hr](#). The DOE projects that this could decrease to as low as [£35/MW/hr](#) by 2035, and companies like Fervo Energy could achieve even lower costs, having already [surpassed](#)

[some DOE estimates](#).

However, the UK will need time to achieve similar cost reductions. The US has benefited from substantial investments in drilling technology due to the shale revolution, providing them with the necessary tools and expertise to develop EGS quickly and cost-effectively. In the short term, the UK lacks this level of expertise and infrastructure. However, much of this technology is transferable, suggesting that the UK could approach these lower costs in the next 3 to 10 years if we commit to a rapid, iterative, and large-scale build out of geothermal wells.

To provide a rough estimate of future costs, we can calculate potential upper and lower bounds. If costs do not decrease at all—a highly unlikely scenario—developing 18GW of geothermal capacity would cost approximately £153.5 billion. If we reach the lower LCOE estimate of £35/MW/hr, the total cost for 18GW of geothermal capacity would be about £46.5 billion, [which is on par with the cheapest existing nuclear plants](#).

How are other countries investing in Geothermal?

Many countries are investing in traditional geothermal energy, but few are currently focusing on EGS. Historically, several nations have attempted to make EGS economical and safe, but setbacks and high costs caused many to abandon these efforts. However, recent advancements in the US and a greater emphasis on clean firm power have made EGS more viable, presenting an opportunity for the UK to become a global leader in this emerging field.

United States

The US is the current leader in both traditional and next-generation geothermal energy. Recent investments include strong backing from the DOE and \$84 million allocated in the Bipartisan Infrastructure Bill. Additionally, geothermal energy is included in the Inflation Reduction Act's investment and production tax credits, roughly equivalent to the US version of the CfD. The US benefits from a robust oil and gas industry that is increasingly motivated to explore lower-carbon energy alternatives. This has led to the rise of promising geothermal start-ups such as [Fervo Energy](#) and [Quaise Energy](#). Favourable legislation also [supports fast drilling](#), similar to benefits seen in the oil and gas sector. At present, no other country matches the US in investment, potential, or technology for EGS.

Iceland

Iceland is another global leader in geothermal power, with 70% of its energy currently derived from traditional hydrothermal sources. Iceland is also a [global leader in soft hydraulic stimulations](#), having performed such treatments on at least 40 wells dating back to the 1970's. Soft hydraulic stimulation is a way to increase the productivity of geothermal in areas where traditional geothermal is only barely viable. It uses less water and pressure than EGS, which reduces costs and seismic risks but cannot be used to fracture harder rock like the granite of Britain.

Recently, however, Iceland has shifted towards drilling deeper rather than relying on hydraulic stimulations. While EGS is excellent for unlocking new geothermal energy regions, it does not fundamentally change how quickly you can harness energy from the ground. To extract more energy, it is crucial to reach hotter rock. Specifically, reaching rock at around 400°C allows water to become supercritical, drastically increasing the speed of energy transfer. However, reaching such hot rock is a significant challenge. At 400°C, drill bits start to melt, rock turns rubbery, and removing debris becomes extremely difficult. For the last twenty years, Iceland has been attempting to overcome these challenges.

Their efforts have been spearheaded by the Iceland Deep Drilling Project. Since 2000, this project has aimed to dig deep enough to [reach supercritical conditions](#). Their first test reached only about 2 km deep before hitting magma, which prevented further drilling. The second test in 2017 was more successful, reaching a depth of 4.5 km, but concerns with the underground rock prevented tests of electricity generation. A third iteration of this project, IDDP-3, is slated to begin drilling [within the next five years](#). Although the project has not yet succeeded, if IDDP-3 manages to create a stable supercritical generator, the potential of geothermal energy could become virtually limitless.

European Union

In the EU, countries have primarily focused on geothermal heating rather than power generation. France and Germany lead this effort, each with more than [400 MW of next-gen geothermal heating projects](#). Over the last decade, Germany has doubled its geothermal heating production and aims to double it again in the next five years. The Netherlands is also rapidly expanding its geothermal supply. While these expansions are mainly in traditional geothermal power, both France and Germany have tested EGS multiple times. However, economic and seismic concerns have prevented widespread adoption.

Rest of the world

A full list of traditional hydrothermal leaders can be found below. Notably, outside of Europe, research into EGS is limited. South Korea had one test site that was shut down following [an induced earthquake](#). China also looked into EGS but [did not conduct any full-sized tests](#). The Philippines did a bit of research in the 90's but has since stopped. Recently, however, [they announced plans to work with US companies](#) to potentially build new plants. Japan is also active in space.

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