Chapter 2

The Geothermal Opportunity in the United Kingdom

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Geothermal can strengthen the UK grid by shifting heat demand off electricity while also adding dependable, weather-independent supply in select locations. For the National Health Service, hospitals' constant heat loads and public procurement can turn geothermal from promising to bankable, lowering emissions and bills while improving resilience. With heat resources widely available, scaling geothermal can cut peaks, reduce costs to consumers, and ease network constraints for decades to come.

The United Kingdom depends heavily on foreign energy. In 2024, net energy imports rose to more than 43% of all energy used.[1] The top import, from Norway, was about 31 billion cubic metres of natural gas, representing roughly 75% of the UK's total gas imports and nearly half of the country's total gas consumption. Yet, the countries that make up the United Kingdom—England, Scotland, Northern Ireland, and Wales—sit on top of a major untapped opportunity.

The UK is home to considerable underground geothermal resources. Project InnerSpace estimates that there are around 3,900 gigawatts of total technical potential for heating and cooling (down to 3.5 kilometres)—and about 25 gigawatts of total technical potential for electricity generation (down to 5 kilometres). (See Chapter 3, "Where Is the Heat? Exploring the United Kingdom's Subsurface Geology," and Chapter 4, "Geothermal Heating and Cooling: Applications for the United Kingdom's Industrial, Municipal, Residential, and Technology Sectors," for extensive mapping of the subsurface resources available to develop geothermal.)

This chapter outlines the projected size of the UK's geothermal opportunity within the context of the nation's current and future energy mix, the potential costs and benefits of geothermal deployment, and tangible opportunities for geothermal expansion across the UK.

SETTING THE SCENE: ENERGY USE IN THE UNITED KINGDOM

Electricity

- In 2025, UK winter peak electricity demand was 47.4 gigawatts, with total annual demand reaching 319,000 gigawatt-hours.[2]
- In 2025, the UK generated roughly 289 terawatt-hours of electricity, with renewables contributing about 44% (127 terawatt-hours). Wind supplied 29.7% (85 terawatt-hours), with a peak capacity of 23.8 gigawatts, while solar produced 6.5% (19 terawatt-hours) and peaked at 14 gigawatts.[3]
- The National Energy System Operator Future Energy Scenarios predict that by 2035, electricity demand will increase to around 450 terawatt-hours, and around half of all homes will have heat pumps, which will more than double electricity demand for home heating, from 25 terawatt-hours to 57 terawatt-hours.[4]

Heating and Cooling

- In 2025, UK annual heating demand was more than 572,000 gigawatt-hours.[5]
- In England, heat networks currently supply around 12.4 terawatt-hours, with targeted expansion to 27 terawatt-hours by 2035—an increase from 3% to 7% of total heat demand. In Scotland, heat network supply targets 7 terawatt-hours by 2035.[6]
- In 2023, around 80% of household bills were spent on heating and hot water.[7]
- UK cooling demand was around 15.5 terawatt-hours in 2021[8] and is expected to rise sharply; London is projected to see the fastest cooling demand growth globally.[9,10]

THE UK'S ENERGY MIX, 2024

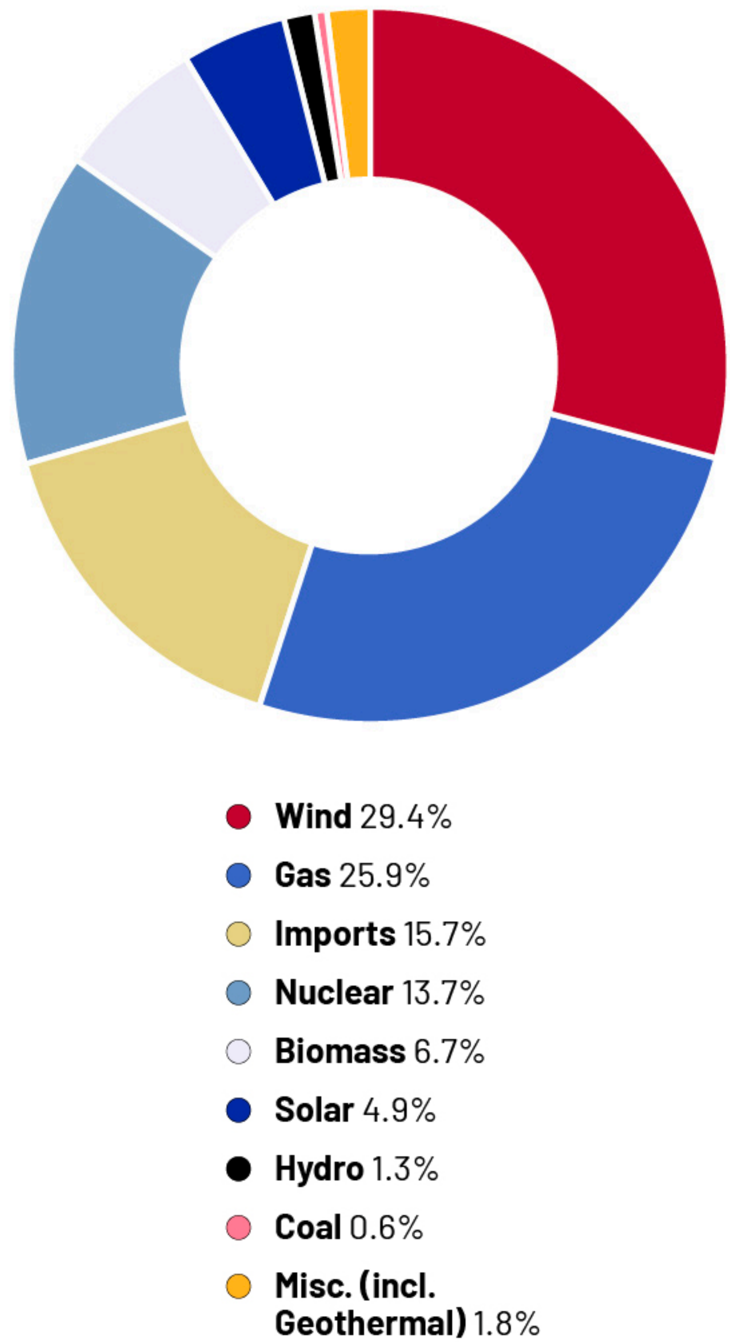

Figure 2.1: The United Kingdom's energy mix as of 2024. Source: Energy Oasis. (n.d.). [The UK's energy mix 2024: Progress, challenges, and what lies ahead].

Geothermal resources could provide the country with a range of domestic, reliable, and secure energy for centuries. Crucially, scaling geothermal—especially for heat, where the resource is most widely available across the UK—can reduce peak electricity demand, lower system-balancing costs, and ease transmission and distribution constraints as the UK decarbonises heating and industry.

The British Geological Survey estimates that the UK has enough geothermal energy resources to meet the UK's entire heating demand for 100 years,[11] while Project InnerSpace analysis undertaken for this report shows there is well over 1,000 years of geothermal heat supply beneath the UK. Despite the availability of resources, geothermal was used for just 0.3% of annual heat demand in 2021, primarily through residential ground source heat pumps.[12]

The UK's geothermal resources could solve a number of domestic problems:

1. Use of imported fossil fuels made up close to 77% of the UK's total energy consumption in 2023. Relying heavily on these sources poses significant energy security risks. International fossil fuel markets are highly volatile; the UK remains exposed to fluctuations in global gas and oil prices, which have driven up energy bills and strained the economy.

2. Reliance on fossil fuels creates greenhouse gas emissions. Under the Climate Change Act 2008, the UK committed to reducing greenhouse gas emissions by 100% of 1990 levels by 2050.[13] Today, the nation aims to fully decarbonise heating across homes, industry, and public buildings in the next 24 years, cutting emissions 50% by 2035 and mobilising £100 billion in private investment by 2030.[14] Though emissions have decreased significantly over the past three decades, progress has lagged. According to the independent Climate Change Committee, the UK is not yet on track to meet its future carbon budgets or its 2050 target—and it won't get on track without implementing significantly stronger policies, particularly in heating, transport, and industry.[15] Considering that close to one-quarter of UK carbon dioxide–equivalent emissions come from fossil fuel combustion in building heating, decarbonising heat is essential to meeting the UK's legally binding climate targets.[16]

WHY DEVELOPING GEOTHERMAL IS A GOOD CHOICE

- **Energy security and independence:** The UK's reliance on imported oil and gas exposes the energy system to geopolitical risk and price volatility. Recent events, including the war in Ukraine, have demonstrated how external shocks can rapidly drive up energy costs and disrupt supply. Local geothermal resources would reduce dependence on foreign energy imports.

- **Low-carbon energy:** Geothermal energy is abundant and sustainable, with minimal greenhouse gas emissions. Investing in geothermal energy will help the UK meet its emission-reduction targets.

- **Lower operational costs:** Geothermal energy has no fuel costs, lacks predictable operating costs, and is significantly more efficient than other heating and cooling technologies, which means it can help reduce costs for consumers and businesses.[17] High system efficiencies also reduce electrical grid demand, and this can have a knock-on effect of reducing electrical costs for neighboring users. Geothermal could therefore reduce operational costs at a project level and at a broader energy-system level.

- **Baseload sustainable energy:** Unlike wind and solar, geothermal provides consistent, 24/7 energy, improving grid reliability and energy security.

- **Reduced demand:** Geothermal systems are typically more efficient than comparative heating and cooling systems.

- **Reduced pressure on the grid:** Networked geothermal systems deliver heat directly to buildings or districts, using significantly less grid electricity than comparative technologies. This helps lower overall electricity demand and reduce stress on the national grid, especially during peak winter periods.

- **Small footprint:** Geothermal has the smallest surface footprint of any renewable energy on an acre-for-acre basis.[18] Ground source heat pump (GSHP) systems are almost invisible, with most of the equipment buried below ground, and deep direct-heat schemes typically require only compact surface energy centres. Next-generation systems reduce this footprint even further.[19] (See Chapter 1, "United Kingdom Underground: An Overview of Geothermal Technologies and Applications," for more.)

- **Jobs and economic opportunity:** Geothermal projects create high-quality, long-term employment—with potentially between 5 and 10 jobs per megawatt deployed[20]—across multiple sectors. Several UK deep geothermal resources are located within regions identified for "levelling up"—areas prioritised for economic investment to reduce regional disparities in wealth and opportunity.[21]

- **Workforce compatibility:** Geothermal development requires skills similar to those needed for the oil and gas and mining industries—drilling, construction, engineering, operations, reservoir management, and more. Fortuitously, the UK has an experienced oil and gas workforce that can be retrained and redeployed, supporting an expansion of jobs and a just transition.

- **Cascaded and multi-use efficiency:** Geothermal energy can be used sequentially for multiple applications—such as electricity generation, industrial heat, district heating, agriculture, and thermal storage—because the water remains warm even after its hottest heat is extracted. This cascaded use maximises the energy extracted from each well, improving overall system efficiency, lowering costs, and increasing the economic and social value delivered per unit of land and infrastructure.[22]

GEOTHERMAL PROJECTS UNDERWAY IN THE UK

Geothermal energy is gaining traction in the UK, with about 30 deep geothermal projects in development, a number of minewater heat and district heating projects underway, more than 55,000 GSHPs installed nationwide,[23] and more than a dozen companies that have secured private and public funding for geothermal projects. (See Chapter 10, "A New Age of Innovation: The United Kingdom's Geothermal Start-Up Scene," for more.) These projects demonstrate geothermal's potential to provide low-carbon, reliable heating and support decarbonisation across homes, businesses, and public infrastructure.

A SELECTION OF MAJOR GEOTHERMAL PROJECTS IN THE UK

Project	Details
Ground Source Heat Pumps (GSHPs)	
Queens Medical Centre, Nottingham	Installing air- and ground source heat pumps with 64 boreholes (to 250 metres). Phase 1 delivers 4 megawatts of heating and 2.88 megawatts of cooling.
British Geological Survey Headquarters GSHP Project	£1.7 m Public Sector Decarbonisation Scheme–funded closed-loop GSHP system with 28 boreholes (to 225 metres), providing 300 kilowatts at 55°C.
Citigen (E.ON), London	2022 upgrade adding heat pumps and three 200 metre boreholes delivering 4 megawatts of heating and 2.8 megawatts of cooling, integrated with district heating networks, combined heat and power (CHP), and thermal storage.
Kensa "Heat the Streets," Cornwall	GSHP rollout across 98 homes, using shared ground-loop arrays; completed in 2023.
Colchester Northern Gateway	Government-funded 800 kilowatt open-loop GSHP for a district heat grid serving 300 homes and health care; uses five Chalk aquifer boreholes.
GeoEnergy NI—Stormont Estate	Feasibility study with four 250 metre hydrogeology boreholes and one 500 metre cored borehole to assess a ~15°C shallow aquifer for heat network design. Public engagement includes the GeoEnergy Discovery Centre.
Underground Thermal Energy Storage (UTES)	
UK ATES Installations	11 aquifer thermal energy storage (ATES) systems deployed in the UK: 9 in London (mainly in the Chalk aquifer), 1 in Manchester, and 1 in Brighton. First system installed in 2006; averaging about one new system per year.
BODYHEAT—SWG3, Glasgow	Low Carbon Infrastructure Transition Programme–funded system capturing body heat from dancers and storing it in shallow geothermal boreholes; 12 boreholes supply heating and cooling to the SWG3 venue.
Minewater	
Lanchester Wines (Felling, Gateshead)	Two commercial minewater heat schemes providing 2.4 megawatts and 1.2 megawatts to beverage warehouses. Drilled in 2015; issues with iron-ochre scaling, corrosion, and reinjection capacity have been progressively resolved. TownRock Energy has managed operations and maintenance since 2021.
Gateshead Mine Water Heating Scheme	Large-scale 6 megawatts thermal minewater system, extracting water from ~150 metres depth to supply offices, municipal buildings, 1,250 homes, an arts centre, and an industrial facility. Funded by the Heat Networks Investment Project and Gateshead Council.
Mining Remediation Authority (MRA) Mine-Water Heat Opportunity Programme	MRA has completed numerous feasibility studies and produced minewater heat opportunity maps for the Welsh coalfield and 10 English cities, integrated into Department for Energy Security and Net Zero Heat Network Zoning Reports.

Project	Details
Minewater	
Dawdon Mine Water Treatment Scheme (Seaham Garden Village)	Construction underway on an energy centre to supply 2.4 megawatts thermal to 750 homes using treated minewater.
South Wales Industrial Unit Scheme	Closed-loop heat exchanger utilising treated minewater to provide approximately 45 kilowatts thermal to an industrial site.
Bolsover District Council (Derbyshire)	Closed-loop scheme planned to use an abandoned flooded coal-mine shaft.
Cornwall Metal Mines (PUSH-IT Project)	Feasibility studies exploring heat and seasonal thermal-storage opportunities in flooded metal mines.
Deep Geothermal Systems	
City of Southampton Energy Scheme	UK's only deep-aquifer geothermal system; draws 76°C fluid from ~1,800 metres depth in the Triassic Sandstone. Began in the 1980s, expanded into a CHP-supported district-heating scheme serving 3,000 homes, 10 schools, and commercial buildings. Geothermal operations resumed after a 2020 pump replacement. Reported carbon dioxide savings of 131,564 tonnes since commissioning.
Bath & Matlock Bath Hot Springs	Long-running hydrothermal systems using naturally heated groundwater from deeply buried early Carboniferous Limestone with significant theoretical resource potential.
Salisbury District Hospital (GT/Star Energy)	Deep geothermal heat project in development to supply more than 20 gigawatt-hours per year for full hospital heat demand; seismic survey completed.
Wythenshawe Hospital, Manchester	Assessment underway for potential deep geothermal heat supply.
GeoEnergy NI—College of Agriculture, Food and Rural Enterprise Greenmount Campus	Feasibility study exploring the Sherwood Sandstone aquifer at approximately 2 kilometres depth. 2023 surveys conducted: gravity, magnetotellurics, and seismic geophysics.
United Downs Deep Geothermal Power Project (Cornwall)	Aims to be UK's first commercial deep-geothermal electricity project. Developed by Geothermal Engineering Ltd (GEL). Uses natural permeability of the Porthtowan Fault in the Carnmenellis granite. Two deviated wells drilled in 2018–19: UD-1 (5,275 metres, ~180°C, production well) and UD-2 (2,393 metres, injection well). A 5 megawatts electric binary plant (export limited to ~3 megawatts electric) was ordered following 2021 hydrotesting. Construction progressed through 2024, with operation expected in 2026. Fluids contain more than 300 ppm lithium, enabling a 100 tonnes per year direct lithium extraction demonstration plant.
Eden Geothermal Project (Cornwall)	Second UK deep geothermal project, developed by Eden Geothermal Ltd. Well EG-1 drilled May–Nov. 2021 to 4,871 metres true vertical depth (5,277 metres measured depth). A coaxial system installed to 3,850 metres has supplied 1.4 megawatts thermal since June 2023 to heat Eden's biomes and greenhouses via a 3.8 kilometre closed-loop. A second deep borehole is planned to create an electricity-producing doublet; waste heat would then supply the biomes.

Project	Details
Planned Deep Geothermal and District Heat Networks Projects	
University of York, Nottingham Queen's Medical Centre	The government also supports public sector decarbonisation, funding geothermal heating networks—and potentially electricity generation in the future—at the University of York (£35 million) and Nottingham University Hospital's Queen's Medical Centre (£36 million).[24]
GEL Cornwall Projects (Manhay, Penhallow, Tregath)	GEL is planning additional deep geothermal projects in Cornwall. Manhay and Penhallow received local planning approval in early 2025, while Tregath is awaiting determination.
NHS Grampian Deep Geothermal Feasibility (Aberdeen)	TownRock Energy is assessing geothermal potential for NHS Grampian across multiple sites in Aberdeen, including wells up to 5 kilometres deep.
Cornish Lithium—Cross Lanes (Chacewater)	Cornish Lithium drilled 8 boreholes to 2 kilometres depth to assess geothermal-brine lithium potential. In 2025, planning permission was granted for a commercial lithium production facility at Cross Lanes, which will also evaluate using the same geothermal fluids for local heat supply.
Weardale Lithium —Eastgate (North East England)	Planning permission granted in 2025 for geothermal-brine lithium extraction on a brownfield site at Eastgate, using existing deep wells for extraction and reinjection.
Swaffham Prior Heat Network (Cambridgeshire)	A village-scale heat network supplying 300 homes and public buildings, using 108 GSHP boreholes and 1.7 megawatts thermal of capacity, integrated with solar and air-source heat pumps.
Sutton Dwellings Retrofit (London)	Social housing retrofit where Kensa and Clarion Group installed 27 boreholes to 180 metres to supply ground-source heating to 81 flats via shared ground-loop arrays.
Geothermal Research	
UK Geoenergy Observatories (UKGEOS)	The UKGEOS facilities provide data on response of the subsurface to thermal, chemical and biological effects of low-carbon energy technologies, specifically UTES. The Glasgow site focuses on minewater heat and thermal storage, while the Cheshire site targets borehole and ATES within the Sherwood Sandstone.
UK FORGE	Funding request for a deep EGS geothermal research project aiming to recreate the significant cost reduction and scientific lessons learnt from the US FORGE and Fervo projects.

Figure 2.2: Major geothermal projects in the UK. Source: Adapted from Monaghan, A. A., Gonzalez Quiros, A., O'Grady, M., & Curtis, R. (2025). *Geothermal energy use, country update for the United Kingdom*. European Geothermal Congress 2025, Zurich, Switzerland; Coal Authority. (2025, March 17). *Mine water heat opportunity mapping for 10 cities in England*. Government of the United Kingdom.

GEOTHERMAL COSTS IN THE UK

Shallow Geothermal Deployment

Geothermal heat pump systems require a higher up-front investment than conventional heating systems: In the United States, these system costs are between $15,000 and $40,000 per home.[25] In the UK, sources indicate that up-front costs are roughly between £10,000 and £20,000.[26] However, they offer substantial long-term energy cost savings, government rebates, and long lifetimes, with additional costs often returned in energy savings in 5 to 10 years.[27] Thermal energy network capital costs are driven by network infrastructure costs, which can be significant (such as close to £12,000 per dwelling in modelled UK cases), but cost benefits come from economies of scale and high-density deployment.[28]

Scaling geothermal heat pumps and thermal energy networks can cut rate-payer energy payments by tens of billions nationally. In the United States, heat pumps can, on average, save more than US$500 per household.[29] Scaling ground source heat pumps could reduce winter peak electricity demand by up to 40 gigawatts, delivering an estimated US$4 billion per year in grid system savings.[30]

> ***In the United States, deploying ground source heat pumps at scale could reduce peak winter demand by up to 40 gigawatts and create US$4 billion of annual grid system savings.***

Cost Structures and Recent Technological Advancements in Deep Geothermal Deployment

The development of deep geothermal energy is often characterised by high up-front capital costs, which remain a key barrier to commercial deployment. These costs are largely driven by exploration and deep drilling, which are essential to confirm subsurface heat reservoirs but are both technically complex and financially risky.

Levelised costs represent the average discounted lifetime cost of constructing and operating a heat or power asset over its operational life. In the UK, levelised costs for geothermal technologies vary considerably due to differences in drilling depth, reservoir conditions, and the technologies deployed. Shallow ground source heat pump systems, particularly when integrated with underground thermal energy storage, currently achieve the lowest estimated levelised costs. Deep geothermal systems face higher costs, primarily due to greater up-front capital expenditures; however, they offer substantial potential for cost reduction as drilling costs fall with market growth and improved learning rates. With continued development and targeted support mechanisms, geothermal energy in the UK has the potential to reach cost parity with more mature European markets.[31]

> ***Insights from more advanced geothermal markets show what is achievable. Emerging technologies—largely from the oil and gas sector—in directional drilling, AI-assisted site characterization, and advanced drilling fluids are reducing costs around the world. Recent results from Fervo Energy in the United States demonstrate significant cost improvements. Between 2022 and 2024, the costs for developing a well dropped by nearly half, and the time it took to drill a well fell by almost 70%.***

Insights from more advanced geothermal markets show what is achievable. Emerging technologies—largely from the oil and gas sector—in directional drilling, artificial intelligence (AI)-assisted site characterisation, and advanced drilling fluids are reducing costs around the world.[32,33,34,35] Recent results from Fervo Energy in the United States demonstrate significant cost improvements. Between 2022 and 2024, the costs for developing a well dropped by nearly half, and the time it took to drill a well fell by almost 70%.[36,37]

Drilling is typically the single largest cost line in a geothermal project (often between around 40% and 60% of capital expenditures, depending on resource depth/temperature and success rates).[38] Major drivers are (i) depth and temperature (hard, abrasive formations; lost circulation); (ii) well design (diameter, casing strings, materials); (iii) rate of penetration and non-productive time; (iv) success rate (dry or underperforming wells); and (v) rig day rates and services tightly linked to the oil and gas cycle.

Low Operational Costs and Long-Term Competitiveness

In contrast with high capital costs, operating costs of geothermal plants are low because no fuel is required. Direct-use applications such as space heating, agriculture, and industrial drying can reduce fuel consumption by up to 80%, while overall operational costs fall by around 8% compared with conventional systems.[39] Globally, operations and maintenance costs for geothermal power plants typically range between US$9 and US$25 (£7–£18) per megawatt-hour, excluding well replacement drilling.[40] This predictable cost structure enhances geothermal projects' long-term economic viability.

Based on data published thus far, drilling and power plant components take up a large share of the costs for a geothermal power generation facility. While geothermal is capital intensive up front, it offers low and stable life cycle costs, positioning it as a firm renewable option that can complement the UK's solar- and wind-heavy system.

EXPANSION OF THE UK'S GEOTHERMAL INDUSTRY: OPPORTUNITIES AND BENEFITS

In any geothermal project, the resources—and their location—are key. As mentioned, the most promising opportunity in the UK is to use geothermal for heat processes. District heating networks are central to the UK government's energy security and decarbonisation strategies, with plans to supply 20% of UK heat demand by 2050 through an investment of £80 billion.[41]

As explained in detail in Chapter 3, "Where Is the Heat? Exploring the United Kingdom's Subsurface Geology," one obvious starting point is the UK's National Health Service (NHS)—one of the world's largest public health systems—where large, always-on heat demand and public procurement can turn geothermal from promising into bankable.

National Health Service: A Key Opportunity

Hospitals and care facilities require constant, high-volume heat for space heating, hot water, and sterilisation. Supported by the UK's decarbonisation and energy security ambitions, hospitals are currently transitioning away from typical gas boilers and chillers to alternative renewable heating and cooling sources, including geothermal. Geothermal heat delivered either on site or via local heat networks offers predictable, low-carbon heat. Because geothermal supplies heat directly, it can also reduce winter peak pressure on the electricity system, which will become increasingly important as the UK's heat supply electrifies.

The UK government's £288 million Green Heat Network Fund has already awarded £22 million to the Langarth Deep Geothermal Heat Network in Cornwall. The project is expected to deliver around 50 gigawatts of heat per year to a new 3,800-unit development and to the Royal Cornwall Hospital starting this year.[42]

The NHS is also a key participant in programmes such as the Public Sector Decarbonisation Scheme, which has committed more than £1.8 billion in grant funding to decarbonise public sector buildings and reduce their emissions.[43] By being an anchor customer—committing early as a large, reliable heat user—NHS trusts can lower future costs and contribute to a resilient, low-carbon heat infrastructure and strengthen the economics of heat networks.

An indication of the scale of the NHS geothermal opportunity is illustrated in **Figure 2.3**. Project Innerspace has identified 301 NHS facilities located above Triassic aquifers, which represent promising deep geothermal targets. These aquifers offer examples of several viable geological and geothermal settings across the UK. Hospitals situated above sufficiently deep, hot, and permeable aquifer units are expected to have some of the strongest geothermal potential, although a full range of technologies—from GSHPs to deep geothermal systems—could offer low-carbon, reliable energy solutions for NHS facilities.

Shallow Geothermal Systems

Along with the NHS opportunity, minewater geothermal, low-temperature aquifer thermal energy storage, and expanded use of GSHPs are three strong options for residential and commercial heating and cooling that can also deliver meaningful grid benefits. Minewater systems can draw heat from abandoned mines that have filled with groundwater—a valuable opportunity for the near 6 million homes (about 25% of the UK's homes[44]) and many businesses located above former coalfields.

In parallel, aquifer thermal energy storage could supply roughly 61% of the UK's current heating demand and 79% of cooling demand,[45] which could significantly reduce peak loads (**Figure 2.4**). (See Chapter 4, "Geothermal Heating and Cooling: Applications for the United Kingdom's Industrial, Municipal, Residential, and Technology Sectors," for more on this topic.)

NATIONAL HEALTH SERVICE (NHS) FACILITIES ACROSS THE UK

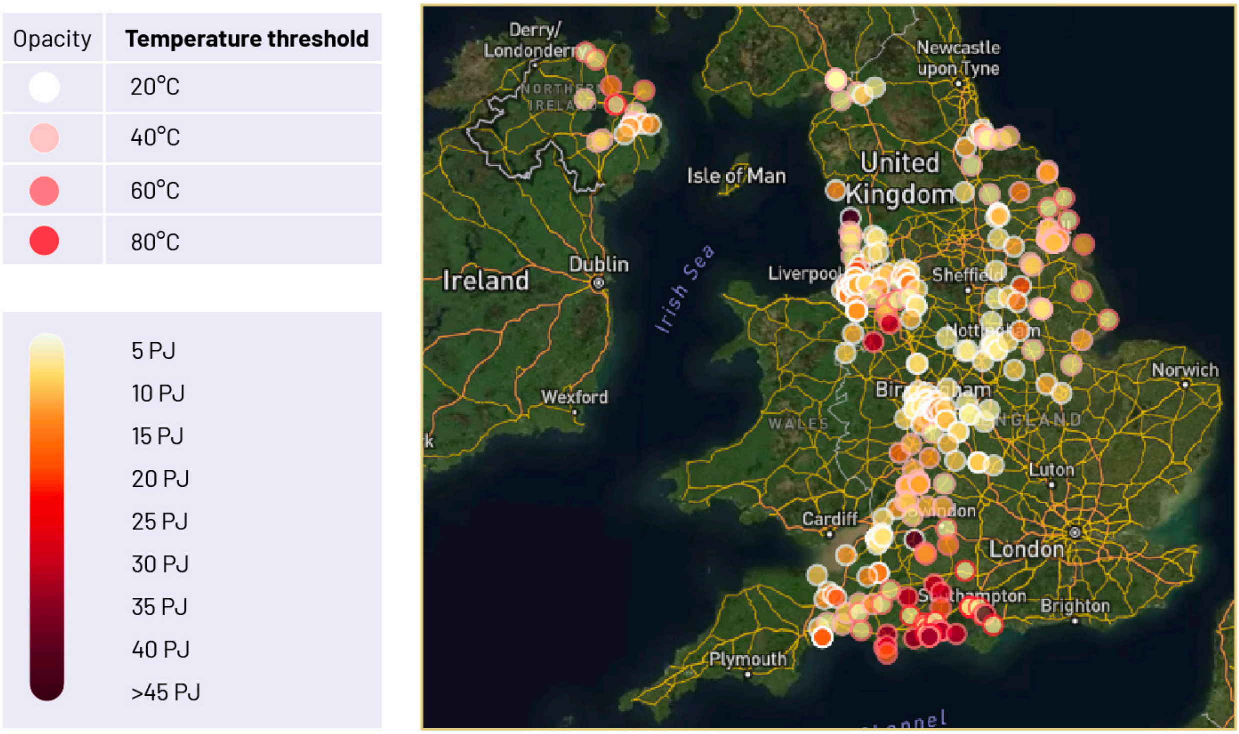

Figure 2.3: Project InnerSpace has mapped 301 National Health Service facilities that are situated over Triassic aquifers, a suitable geothermal target. Hospitals that lie over sufficiently deep (and hot) and permeable aquifer units are considered to have the greatest geothermal potential. 1 PJ (petajoule) = roughly 278 gigawatt-hours. Source: Project InnerSpace.

GSHPs are another scalable pathway because heat dominates building energy use, as about 80% of household energy goes to space heating, water heating, and cooking.[46] UK geothermal cost estimations highlight that GSHP systems used for combined heating and cooling benefit from reduced levelised costs because of greater system use and efficiency (relative to GSHP systems used for heating only or cooling only). That means lower bills.

Building district networks that can heat and cool, or that are coupled with thermal storage, can likewise reduce GSHP costs.[47] From a grid perspective, efficient heat pumps and networked geothermal systems reduce total electricity consumption per unit of heat delivered[48] and can lower peaks and reduce costs.[49]

These pathways—minewater, thermal energy storage, and GSHPs—represent a large technical opportunity. Countries such as France, Germany, and the Netherlands have developed policies to allow them to better tap into their geothermal heating opportunity, and these policies could be models for the UK (see Chapter 5, "Clearing the Runway: Policies and Regulations to Scale the United Kingdom's Geothermal Potential"). Even partial deployment of any of these solutions can reduce system costs and improve resilience.

Several research organisations and companies have secured millions in funding to explore geothermal energy and heating potential in England and elsewhere. (See Chapter 10, "A New Age of Innovation: The United Kingdom's Geothermal Start-Up Scene," for a detailed list.) Funding from the Green Heat Network Fund, the Public Sector Decarbonisation Scheme, and local pilot projects show growing governmental support.

The UK government recently announced a series of reforms intended to create "a more secure and more efficient energy system," in part through the development of a Strategic Spatial Energy Plan. Though the programme is still a work in progress, the government says it will include planning reforms and other efforts intended to encourage more renewable energy investment and development.[50]

Industrial geothermal heat can reduce reliance on gas-fired process heat, easing constraints on gas and power systems during cold spells when demand spikes across the economy.

The government's Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050 identify the eight most heat-intensive sectors as oil refining, chemicals, food and drink, glass, ceramics, cement, pulp and paper, and iron and steel.[51] While not explicitly mentioned in the Roadmaps, geothermal heat could be widely deployed across these industries, provided temperatures meet the required demand and the economic case is viable. Geothermal energy could also be used to supply baseload heating for greenhouses (as in the Eden Project, highlighted more in Chapter 7, "Environmental Stewardship in an Energy-Abundant Future: Considerations and Best Practices"), crop drying facilities, aquaculture, and housing livestock. Industrial geothermal heat can reduce reliance on gas-fired process heat, easing constraints on gas and power systems during cold spells when demand spikes across the economy. (See Chapter 4, "Geothermal Heating and Cooling: Applications for the United Kingdom's Industrial, Municipal, Residential, and Technology Sectors.")

SEASONAL OPERATION OF LT-ATES IN SUMMER AND WINTER

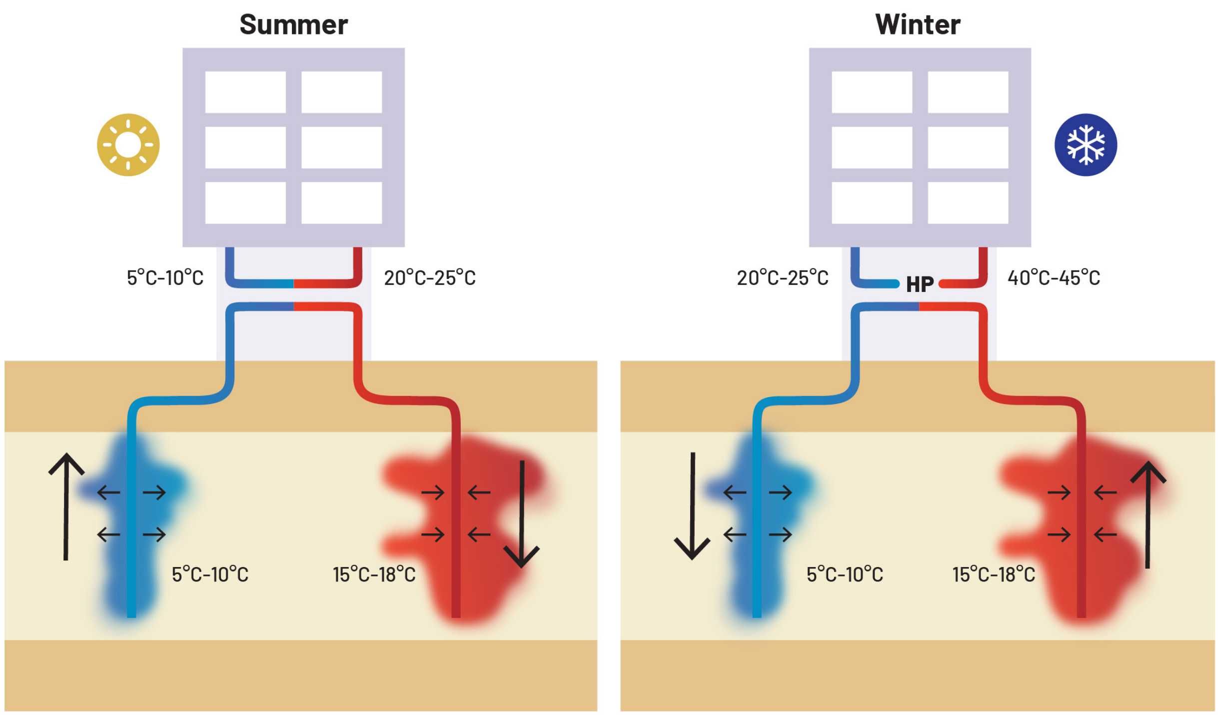

Figure 2.4: Seasonal operation of low-temperature aquifer thermal energy storage (LT-ATES) in summer (left) and winter (right). HP = heat pump. Source: Jackson, M. D., Regnier, G., & Staffell, I. (2024). [Aquifer thermal energy storage for low carbon heating and cooling in the United Kingdom: Current status and future prospects](). *Applied Energy, 376*, 124096.

Opportunities for Geothermally Cooled Data Centres

The rapid expansion of the UK's AI and data centre sector is driving unprecedented demand for cooling, which currently accounts for around 40% of data centre electricity use and is predicted to rise. Two of the government's AI Growth Zones—Culham, Oxfordshire, and the north-east's Northumberland and North Tyneside—also have thick sedimentary basins where geothermal cooling could be deployed and help reduce costs and energy demand.

Shallow aquifers and abandoned mines that have filled with groundwater can provide widespread low-carbon cooling and thermal storage. Using these resources would help reduce energy demand, peak loads, and emissions for large AI campuses. These same systems can also help turn a data centre from a "pure load" into a local heat asset: The low-grade waste heat rejected during cooling can be captured and upgraded (typically via heat pumps), then fed into nearby residential or municipal heating networks. In a geothermal heat-network context, that recovered heat can complement geothermal baseload—especially during shoulder seasons—helping balance supply and demand, improving overall network efficiency, and reducing the amount of new generation capacity needed to meet peak heating loads. What's more, there are more than 200 additional sites under government consideration with similar subsurface potential. (See Chapter 4 for more details and site-specific opportunities for geothermal data centre cooling.)

Opportunities in Deep Geothermal and Electricity Generation

Over the past few decades, the UK has made considerable efforts to decarbonise its electricity production primarily by shifting to renewable energy sources. In 2013, coal power made up 39.6% of electricity generation; by 2023, it was just 1%.[52] In 2020, for the first time, electricity generation came predominantly from renewable sources solar and wind. The following year, the largest overhaul to the UK's grid system began. The Great Grid Upgrade consists of 17 infrastructure projects across the country to increase the grid's clean energy capacity and transmit electricity more efficiently.[53]

Still, the largest single energy source today for the UK's electric grid is natural gas.[54] What's more, the transition away from fossil fuels in transportation, heating, and industrial use is expected to significantly increase electricity demand.[55]

Geothermal doesn't currently contribute meaningfully to electricity generation everywhere, but subsurface resources indicate that it could in some regions. Granite deposits such as the Cornubian Batholith in Cornwall and Devon show the best technical potential for electricity generation. Subsurface resources in sedimentary basins in Cheshire, Wessex, East Yorkshire, and Lincolnshire and across Northern Ireland—while modest—may also show some electricity generation potential as cost curves decrease and show strong potential for heat. (See Chapters 3 and 4 for detailed subsurface mapping and technical assessments.)

The Benefits of Geothermal for the UK's National Grid

The modern electricity grid is a delicate system that requires constant monitoring to balance electricity production against electricity demands. The UK's transmission infrastructure is extensive and interconnected with neighbouring countries, so energy can be exported and, as is largely the case with the UK, imported.[56]

Because geothermal resources can be used to generate electricity in some locations—and heat, regardless of weather conditions—it can offer various key direct and indirect advantages for the grid:

1. **Peak load management and load shaping for geothermal heat:** Shallow geothermal methods can store and directly supply heat to urban centres, reducing electricity demand for heating during winter peaks. By storing thermal energy with ground or water loops, geothermal systems can preserve energy during off-peak periods and deliver heating (or cooling) during peak hours, helping balance energy supply and demand and improve overall efficiency.[57] Use of geothermal heating flattens the load profile, reduces peak strain on the grid, and indirectly lowers costs associated with electricity generation,

transmission, and balancing (see "The Benefits of Geothermal Storage" for more information).

2. **Enhanced stability:** Geothermal power plants have a high capacity factor, typically in the range of 90% or more, meaning they operate near full output for most hours of the year.[58] As a firm, low-carbon baseload resource, geothermal provides consistent power to the grid, reducing reliance on fossil fuel-based generation during periods of peak demand and low renewable output.

3. **Improved resilience:** Unlike solar and wind, geothermal energy production remains largely unaffected by surface weather and can quickly return to operation after disruptions or extreme events. By prioritising investment in geothermal, regions prone to severe weather could significantly enhance grid resilience, reducing the likelihood of future outages, such as those that took place after severe windstorms in the UK in late 2024 and early 2025.

4. **Reduced transmission losses:** Locating geothermal deployments near demand centres minimises the distance electricity must travel, reducing energy losses. Additionally, geothermal is often structurally built close to energy demand (unlike solar and wind, which are often located where resources are strongest, such as offshore), which can alleviate local congestion and improve delivery efficiency. For example, curtailment of renewable energy in the UK (due to grid constraints and transmission bottlenecks) amounted to 5.8 terawatt-hours of wind energy in 2020 through 2021—enough to power 800,000 homes annually.[59] Locally embedded geothermal generation can help avoid similar inefficiencies.

5. **Transmission line capacity:** Geothermal plants produce steady, predictable output, allowing existing transmission lines to be used more efficiently and reducing the need for new infrastructure. An analysis by U.S. national labs (National Renewable Energy Laboratory and Oak Ridge National Laboratory) found that widespread deployment of geothermal heat pumps could reduce the need for new long-distance transmission lines by about 33% because these pumps reduce total electricity generation and peak demand compared with other pathways.[60] This deployment can lower system costs and ease congestion without requiring any changes to grid operations.

With the right policy support and financial mechanisms, developers can accelerate deployment of geothermal energy (see Chapter 5, "Clearing the Runway: Policies and Regulations to Scale the United Kingdom's Geothermal Potential," and Chapter 9, "Minding the Gap: Financing Solutions to Advance Geothermal in the United Kingdom"). In the near term, targeted geothermal projects can provide meaningful grid support, resilience, and decarbonisation benefits at the community and city levels and, as momentum builds, unlock increasing national benefits over time.

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The Benefits of Geothermal Storage

As the UK relies more on wind and solar power for electricity generation, the share of intermittent power sources—available only when the sun shines or the wind blows—increases. As a result, energy storage will be necessary to maintain grid stability. The UK's National Energy System Operator estimates that overall electricity peak demand will almost double until 2050, with significant growth driven by new data centres used to power AI.[61]

Worldwide, hydroelectric storage provides most energy storage capacity today. There has also been a big expansion in the deployment of batteries for energy storage. Geothermal adds another option: underground thermal energy storage (UTES), which can capture and store waste heat in subsurface storage spaces such as aquifers, boreholes, and mines (see Chapter 1, "United Kingdom Underground: An Overview of Geothermal Technologies and

Applications," for details). In practice, UTES can be paired with heat networks and GSHP systems to store surplus heat—including summer heat rejected from buildings such as data centres, industrial waste heat, or during periods of solar and wind overproduction—and deliver it when needed in winter.

For the UK grid, shallow geothermal energy storage can have a "whole system" impact. UTES shifts energy use away from peak hours and seasons, reducing peak generation costs and lowering strain on transmission and distribution networks. By storing heat when renewable electricity is plentiful and cheap, and using it later to meet heating demand during peak periods, UTES can reduce winter peak electricity loads that would otherwise rise as heat electrifies. UTES also helps absorb periods of excess renewable output—turning potential curtailment into usable thermal energy—while improving resilience by keeping critical heat services running with less dependence on real-time grid conditions.

UTES could be a good option for locations in areas with significant wind production and sedimentary basins, such as North East Lincolnshire.

CONCLUSION

The UK's geothermal opportunity is fundamentally a grid opportunity: Scaling geothermal heat can change the shape of electricity demand, while targeted geothermal power can add firm, weather-independent capacity in select locations. By supplying heat directly—through aquifer thermal energy storage, ground source heat pumps, minewater systems, heat networks, and direct heat from deep geothermal wells—and adding targeted geothermal power where resources allow, geothermal can ease the operational and infrastructure pressures created by rising electrification and an increasingly wind- and solar-heavy grid.

Going big on geothermal heat helps the grid in three practical ways. First, it reduces peak electricity demand, especially in winter, by shifting heating load off the power system and into direct thermal supply. Second, when paired with thermal storage in the ground or water loops, geothermal systems can absorb energy during low-demand periods and deliver heat when needed—flattening load profiles, reducing peak strain, and supporting system balancing as variable renewables expand. Third, geothermal's proximity to demand centres can reduce congestion and transmission losses and—by lowering overall and peak electricity needs—help limit the scale of new long-distance transmission required under other decarbonisation pathways.

Targeted geothermal power adds a complementary benefit: firm, weather-independent generation with high capacity factors,[62,63,64] which strengthens grid stability and resilience when wind and solar output is low. While geothermal is not likely to dominate UK electricity supply, it can be a strategically valuable option in specific locations—especially where it can be co-located with large loads and integrated into heat-and-power configurations.

In summary, geothermal heating and electricity can accomplish several goals:

- Lower peak strain on the grid, particularly in the winter.
- Improve energy balance in a renewables-heavy system.
- Deliver energy more efficiently.
- Provide dependable clean capacity.

Geothermal can become a cornerstone of a more resilient, lower-cost energy system—not only by decarbonising heat but also by making the electricity grid easier to operate and less exposed to peaks and constraints and lowering costs for consumers.

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