Technology Fact Sheet

Beneath the surface

Geothermal's role in delivering clean heating, cooling and power

Energy Transitions Commission

Next-generation geothermal

JULY 2026

This technology fact sheet is part of the ***Beneath the surface*** series. Each highlights a key technological innovation that can drive geothermal's role in delivering clean heating, cooling and power.

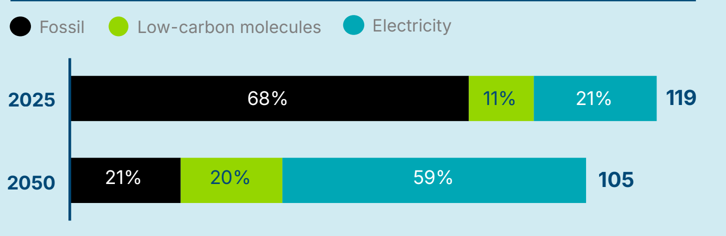
Learn more at www.energy-transitions.org/beneaththesurface

The ETC's energy transition vision

A net-zero global energy system is possible by 2050, driven by clean electrification:

- Electricity increases from 20% to 60%+ of final energy demand, which decreases overall due to energy productivity gains.
- Solar and wind can provide 75%+ of power system generation in most systems, supported by batteries, flexibility and other firm power sources.
- Some flexible dispatchable power capacity will be needed to complement variable renewables.

Global 2025 and 2050 final energy demand breakdown by source (ETC Accelerated but Clearly Feasible scenario) '000 TWh



Technology overview and status: Next-generation geothermal technologies engineer the reservoir instead of relying on a natural one and include enhanced geothermal systems (EGS), closed-loop geothermal systems (CLGS) and superhot rock.

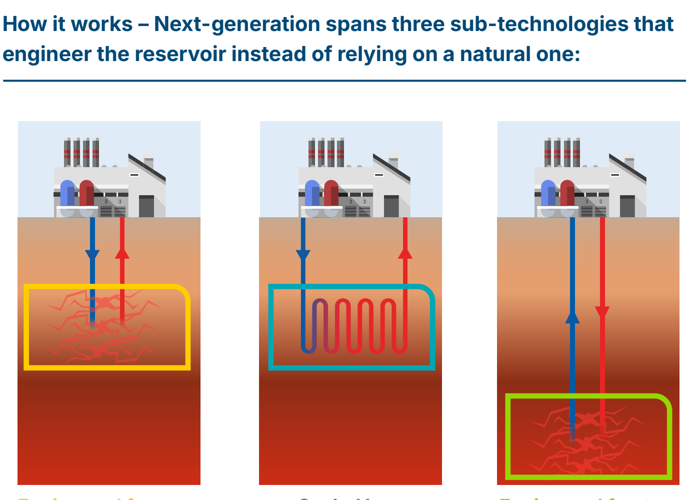
1. Shallow geothermal
   - Ground-source heat pumps
   - Underground thermal energy storage
2. Conventional hydrothermal
3. Next-generation geothermal
   - EGS, CLGS and Superhot Rock

Technology overview and status:

Geothermal Technology	Typical depth (km)	Resource temperature (°C)	Application	Surface technology	Geographic technical potential	TRL	Current global capacity
Next-generation geothermal	2 – 20+ km	EGS & CLGS: 80 – 300 °C; Superhot rock: 375 – 500 °C	Heating and power	Turbine / heat exchanger	Anywhere	3-7	~ 0; ~10 MW-e EGS; + 100 MW-e EGS by 2027

Techno-economics: Next-generation geothermal technologies can provide heat and power almost anywhere but are commercially unproven – first-of-a-kind costs vary up to 100x, and reservoir performance is not yet demonstrated.

How it works – Next-generation spans three sub-technologies that engineer the reservoir instead of relying on a natural one:



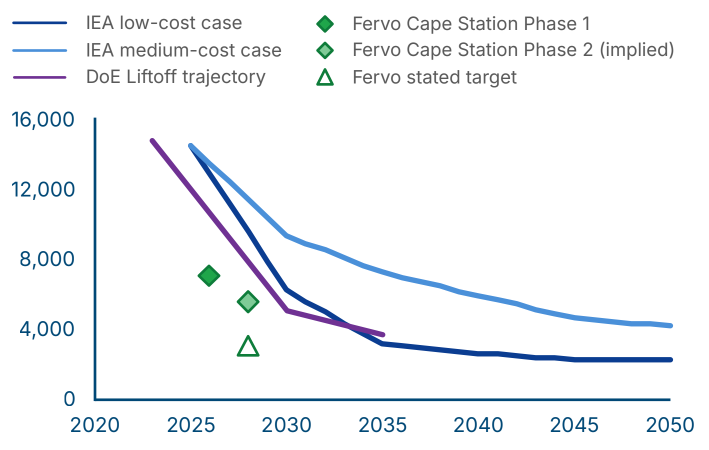
Engineered fracture | Sealed loop | Engineered fracture at ultra-depth

1) Enhanced Geothermal Systems (EGS - TRL 7): Paired wells drilled into hot dry rock, hydraulically stimulated to create an engineered fracture network. *Example: Fervo's Cape Station*

2) Closed-loop Geothermal Systems (CLGS - TRL 6): Working fluid circulates through sealed wellbores, taking heat by conduction only – no rock contact. *Example: Eavor's Geretsried*

3) Superhot rock (SHR - TRL 3-5): EGS at >375 °C, needing novel plasma or millimetre-wave drilling. *Example: Mazama Energy, Newberry*

EGS FOAK projects in the US are aligned with modelled costs $/kW-e, real 2024



Costs are falling in the US but stay unproven outside:

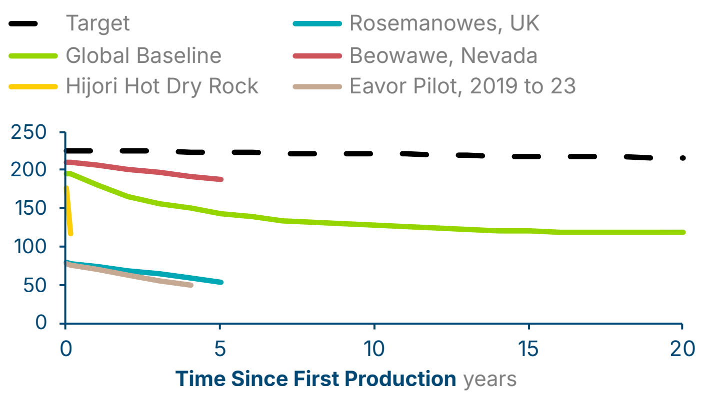
In high-gradient US sites, EGS first-of-a-kind CAPEX is ~$7,000/kW-e (over $100/MWh-e) and n^{th}-of-a-kind projected to be $3,000/kW-e by 2050 (~$50/MWh-e), competitive against onshore renewables and firm low-carbon alternatives.

Limited demonstration project data is available outside the US, with the transferability of US drilling-cost declines to other geologies is the key uncertainty for cost trajectories.

Two key technical uncertainties:

1) Thermal drawdown and
2) Parasitic loads will define long-term reservoir performance and lifetime costs and are critical to proof commercial viability.

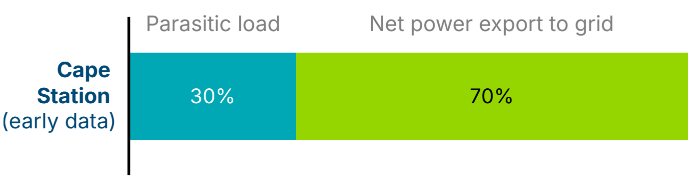
Thermal drawdown of reservoirs is a key risk for next-generation geothermal projects, Fluid/formation temperature over time °C



Thermal drawdown: The heat from the reservoirs is not endless; if they cool or degrade faster than expected, costs will increase as quality and volume of energy decreases.

Early precedent is cautionary: Pre-Fervo pilots (Hijori, Japan; Rosemanowes, UK; Beowawe, US) showed steep thermal drawdown within five to ten years of first production.

Parasitic loads to pump cool water to high depths can have significant impacts on net power output % output

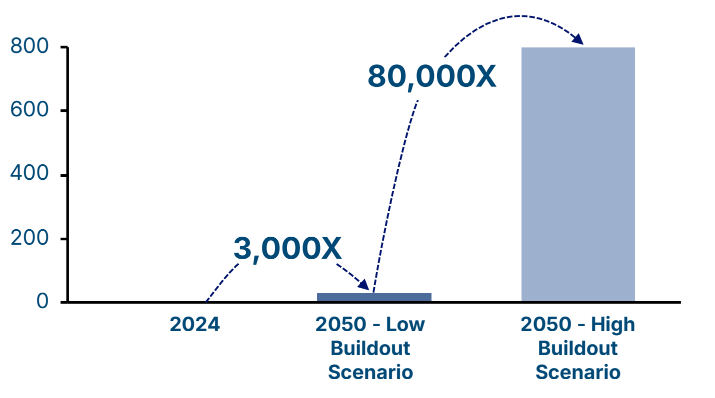


Parasitic loads: Pumping cool water thousands of metres down into dense rock requires significant pressure and, with that, power - "the parasitic load". This reduces net power or heat delivered; ~30% of gross power production in early Fervo Cape Station data.

Evidence outlook: The next 3–5 years of Cape Station operating data will be key to resolving these uncertainties in a US high-temperature resource setting, but a wider demonstration base across regions with other subsurface characteristics is needed to inform wider scalability.

Deployment prospects: Pre-commercial today (TRL 3–7) and long-term growth remains highly uncertain. However, investment has surged in recent years, concentrated in the US and driven by data-centre power demand.

Global next-gen. (EGS) estimated power capacity, 2024 and 2050 (IEA estimates) GW-e



Surge in recent investment:

Increased ~80% year-on-year to ~$2.2 billion in 2025 (from $20 m in 2018), concentrated in the US and anchored by data-centre offtake.

Flagship projects:

Fervo's Cape Station EGS (US); Eavor's Geretsried CLGS (Germany); superhot pilots in Oregon (Mazama, Quaise).

High but uncertain 2050 potential:

Power could reach 30–800 GW-e (0.3–8% of global generation); heat could reach 150–4,200 TWh-th (0.2–5% of consumption), meeting ~4% of district heat, ~9% of industrial heat. This range is dependent on early cost reductions and certainty over thermal drawdown risk.

Barriers to deployment: Unproven reservoir performance, cost transferability, induced seismicity (EGS) and regulatory novelty – not resource availability.

Reservoir performance, longevity, parasitic load

Sustained thermal output over a 20-year life is not yet proven; early pilots showed steep thermal drawdown. Parasitic loads (~30% in early projects) limit net output.

Cost & transferability

First-of-a-kind costs vary significantly; whether the cost declines seen in high-gradient US sites transfer to other geologies is unproven.

Induced seismicity (EGS & superhot rock):

EGS hydraulic stimulation can trigger earthquakes (Pohang 5.4 magnitude, Basel 3.4 magnitude); managed via traffic-light protocols and monitoring. CLGS avoids this risk.

Regulatory & financing novelty

Permitting for next-generation projects is undefined in most markets, and first-of-a-kind projects struggle to attract finance given subsurface and performance risk.

Next-generation environmental risk is technology-specific – manageable, but higher for EGS than CLGS.

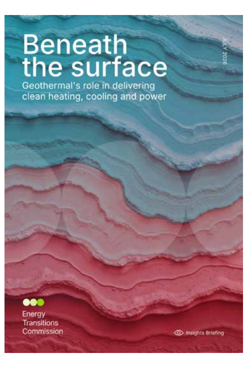
- Induced seismicity is specific to EGS (hydraulic stimulation, as in shale gas) – managed via traffic-light protocols and micro-seismic monitoring; CLGS avoids it entirely.
- EGS and CLGS need groundwater protection through casing and cementing; no EGS groundwater contamination has been documented t o date.
- CLGS has a materially lower environmental risk profile than either EGS or hydraulic fracturing for hydrocarbons.

Policy actions: De-risk first-of-a-kind projects and build fit-for-purpose regulation to test whether US cost declines transfer.

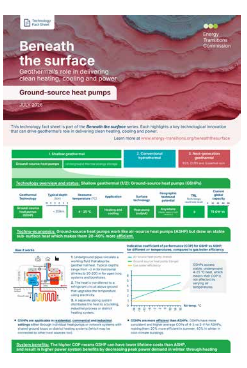
Next-generation geothermal enabling actions and lead actors

	Action	Lead actors
1	**De-risk first-of-a-kind projects** Offer exploration grants, drilling-risk insurance, contracts-for-difference and public co-investment to share FOAK risk.	National governments, treasuries, green investment banks.
2	**Build fit-for-purpose regulation** Introduce induced-seismicity protocols for EGS and clear permitting categories for CLGS (as typically not covered in existing geothermal codes).	Regulators, environment agencies, seismic authorities, permitting bodies.
3	**Anchor offtake demand** Target 24/7 clean-power power purchase agreements (e.g., data centres) and industrial heat contracts in high-gas-price markets.	Utilities, data-centre and industrial off-takers, system operators.
4	**Leverage oil and gas capacity** Deploy transferable drilling rigs, crews and subsurface expertise into geothermal at competitive returns.	Oil and gas companies, drilling contractors, governments, trade associations.
5	**Fund demonstration across geologies** Prove reservoir performance and cost-decline transferability beyond high-gradient US sites through test centres and demonstration projects.	Research agencies, national labs, developers.

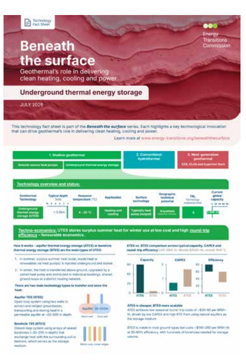
Further reading In the Beneath the Surface series



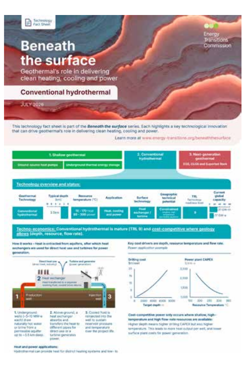
Beneath the Surface Insights Briefing Main Report



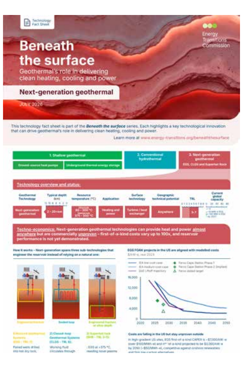
Ground-source heat pumps Technology Fact Sheet



Underground thermal energy storage Technology Fact Sheet



Conventional hydrothermal Technology Fact Sheet



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Sources and notes

The ETC's energy transition vision: ETC (2025), *Carbon in an electrified future: Technologies, trade-offs and pathways*.
Techno-economics: Systemiq analysis for the ETC (2026); BNEF (2025), *US Next-Generation Geothermal Makes Unsung Progress;* US DoE (2024) *Pathways to Commercial Liftoff: Next-Generation Geothermal Power Updated;* IEA (2024), *The Future of Geothermal Energy*; Fervo Energy Inc. (2026), *Form S-1 Registration Statement, filed with the US Securities and Exchange Commission.* Available at https://www.sec.gov/Archives/edgar/data/1853868/000162828026025821/fervoenergy -sx1.htm [Accessed 05 2026]
Two key technical uncertainties: Thunder Said Energy (2026), *Fervo Energy: it's all about the reservoir?!* Available at http://thundersaidenergy.com/ [Accessed 07 2026]; GEO ExPro (2026), *World's largest geothermal reserves?* Available at: <https://geoexpro.com/worlds-largest-geothermal-reserves/> [Accessed 06 2026]
Deployment prospects: Systemiq analysis for the ETC (2026); IEA (2024), *The Future of Geothermal Energy.*
Barriers to deployment: Systemiq analysis for the ETC (2026).
Policy actions: Systemiq analysis for the ETC (2026).

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