Eavor Loop & the Deep Geothermal Frontier

State of the Art, Depth Limits & 150–180 °C Resources

2025-07-03

🔥 Why Deep Geothermal?

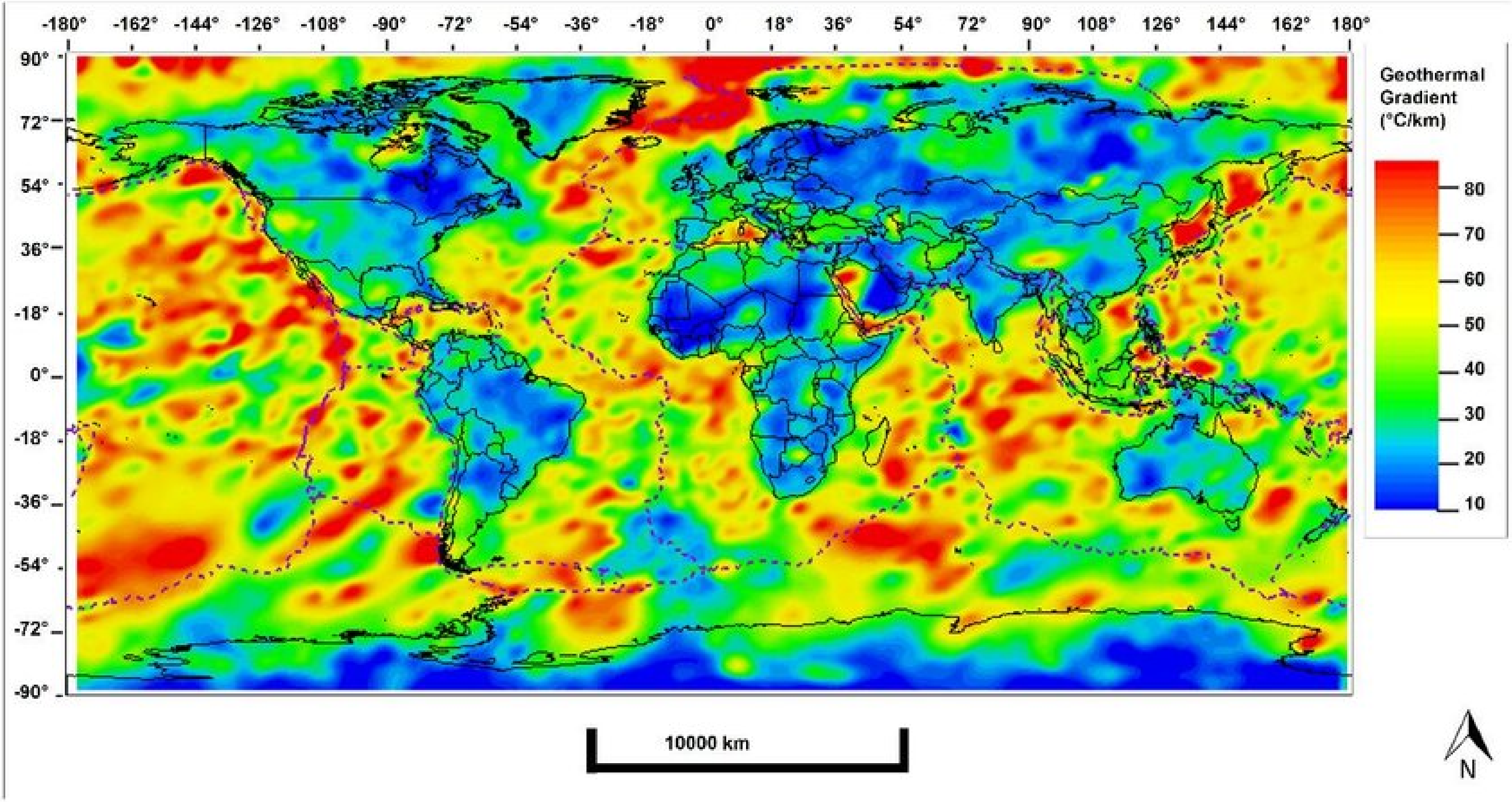
A Sustainable, Always-On Energy Source for Our Community

Benefit	Description
✅ **Stable, 24/7 Power**	Runs year-round, day and night — **reliable baseload** unlike solar or wind
✅ **Small Surface Footprint**	Compact wellpads — ideal for urban, rural, or agricultural land use
✅ **Century-Scale Lifespan**	Closed-loop systems last **100–200+ years** with minimal maintenance
✅ **No Emissions or Fluid Loss**	**Fully sealed systems** — no fracking, no leaks, no aquifer contamination
✅ **District Heating Ready**	Ideal for **neighbourhood-scale heat networks** alongside electricity
✅ **Energy Independence**	Locally sourced — reduces reliance on imports or unstable grid power

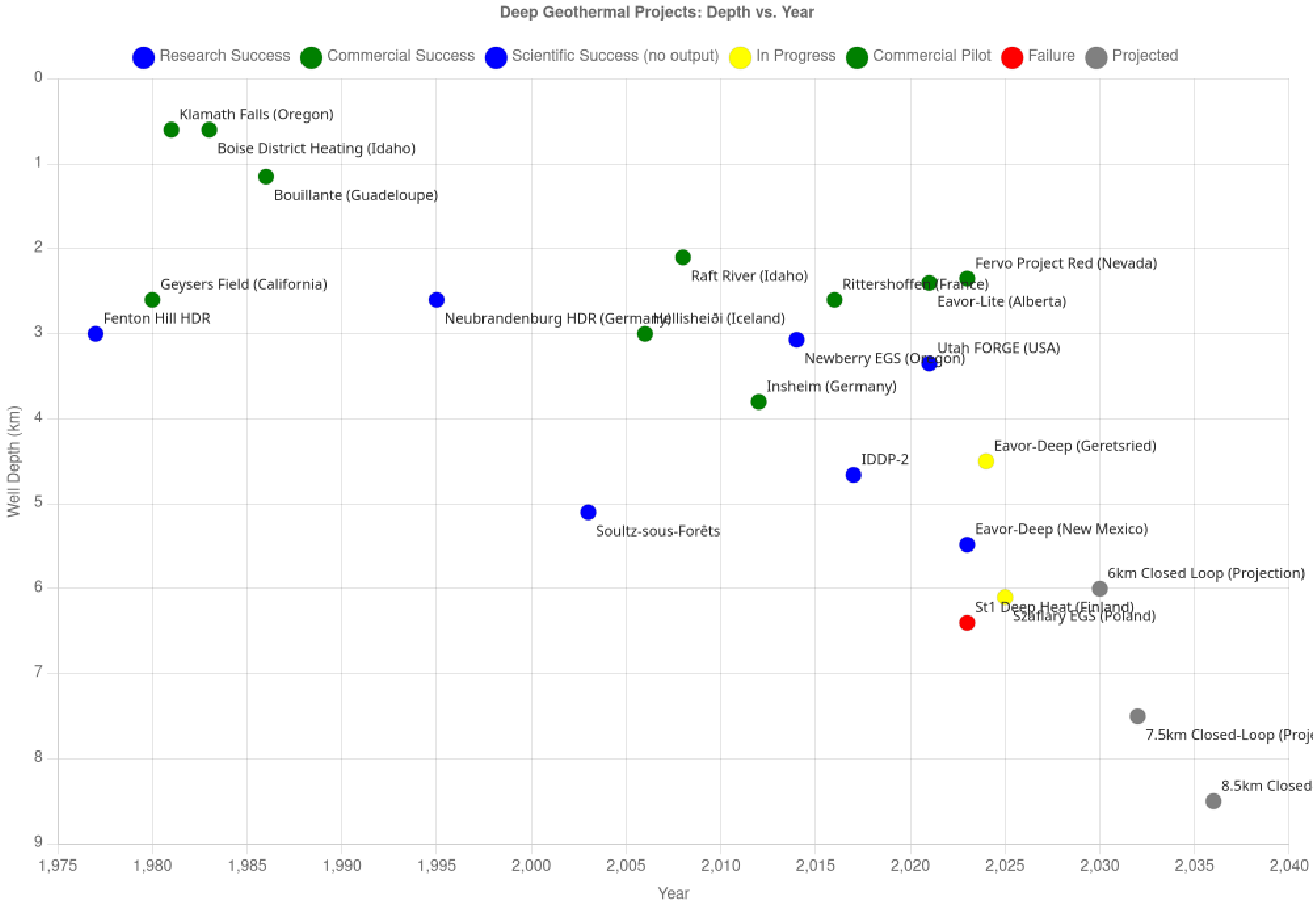
🌍 Global Geothermal Access Roadmap by Depth

Depth to Resource	Viable Land (%)	Target Temp (°C) (+ Typical Gradient)	Geological Context	First / Projected Success Year & Type
2–3 km	~5–10%	150–250 °C (~60–100 °C/km)	**Volcanic/Rift zones:** California (The Geysers), Nevada, Iceland, Kenya Rift Valley, Indonesia, Philippines	1980 – *The Geysers*, CA (EGS)
4–5 km	~15–20%	120–180 °C (~30–45 °C/km)	**High heat flow basins:** Insheim (Germany), Raft River (USA), Tuscany (Italy), Alsace (France), Geretsried (Germany)	**2025/26** – *Eavor-Deep*, Germany (Closed-Loop)
6 km	~35–45%	120–150 °C (~20–30 °C/km)	**Sedimentary basins, shield margins:** Alberta Foothills, Southern Ontario, Central Poland, Sichuan Basin (China)	2031 – Projected Closed-Loop
7 km	~50–60%	120–150 °C (~17–25 °C/km)	**Moderate crustal heat zones:** Illinois Basin (USA), Southern Manitoba, Eastern Ukraine	2035 – Projected Closed-Loop
8 km	~65–70%	120–150 °C (~15–20 °C/km)	**Stable cratonic interiors:** Canadian Shield (ON, QC), Central Australia, U.S. Midwest, Eastern Europe	2039 – Projected Closed-Loop
9 km	~80–90%	120–150 °C (~13–17 °C/km)	**Deep crust continental interiors:** Russia (Urals), Kazakhstan, Eastern Germany, U.S. Interior Plains, Northern China	2044 – Projected Closed-Loop
10 km	~90–95%	120–150 °C (~12–15 °C/km)	**Global near-universal access:** Most of Earth excluding extreme permafrost and ultra-thick shields	2050 – Projected Closed-Loop

Global Geothermal Gradient Map (by Carlos Vargas)



Historical Depth Milestones



🧯 Why EGS Fails Below 4 km

❌ EGS Needs Proppant to Work

EGS relies on fracturing deep rock to create fluid pathways.

Proppant (like sand or ceramic beads) keeps fractures open.

But at depths >3.5–4 km, pressures exceed 100 MPa:

All known proppants crush or deform

Fractures seal shut, stopping flow

Result: Flow drops within months without costly re-fracturing.

❌ EGS Case Studies and the Proppant Failure Limit (~3.5–4 km)

Project	Year(s)	Depth	Outcome	Lesson
St1 Deep Heat (Finland)	2016–2023	6.4 km	❌ Failed – rapid injectivity loss	Proppants crushed at >100 MPa; unviable
Basel EGS (Switzerland)	2006–2009	5.0 km	❌ Halted – induced seismicity	Fractures self-seal + seismic risk
Soultz-sous-Forêts (France)	1995–ongoing	5.1 km	🔵 Research – repeated stim failures	Permeability degrades within weeks/months
Baca HDR (New Mexico, USA)	1981–1998	3.0 km	❌ Abandoned – injectivity drop	Even at 3 km, fractures rapidly closed

✅ Closed-Loop Systems Are the Solution

No fracking, no proppant, no fluid loss

Can operate reliably beyond 6–8 km

Eavor-Deep NM proved tech at 5.5 km, 250+ °C

Ideal for Ontario: target 7–8.5 km for 150–180 °C

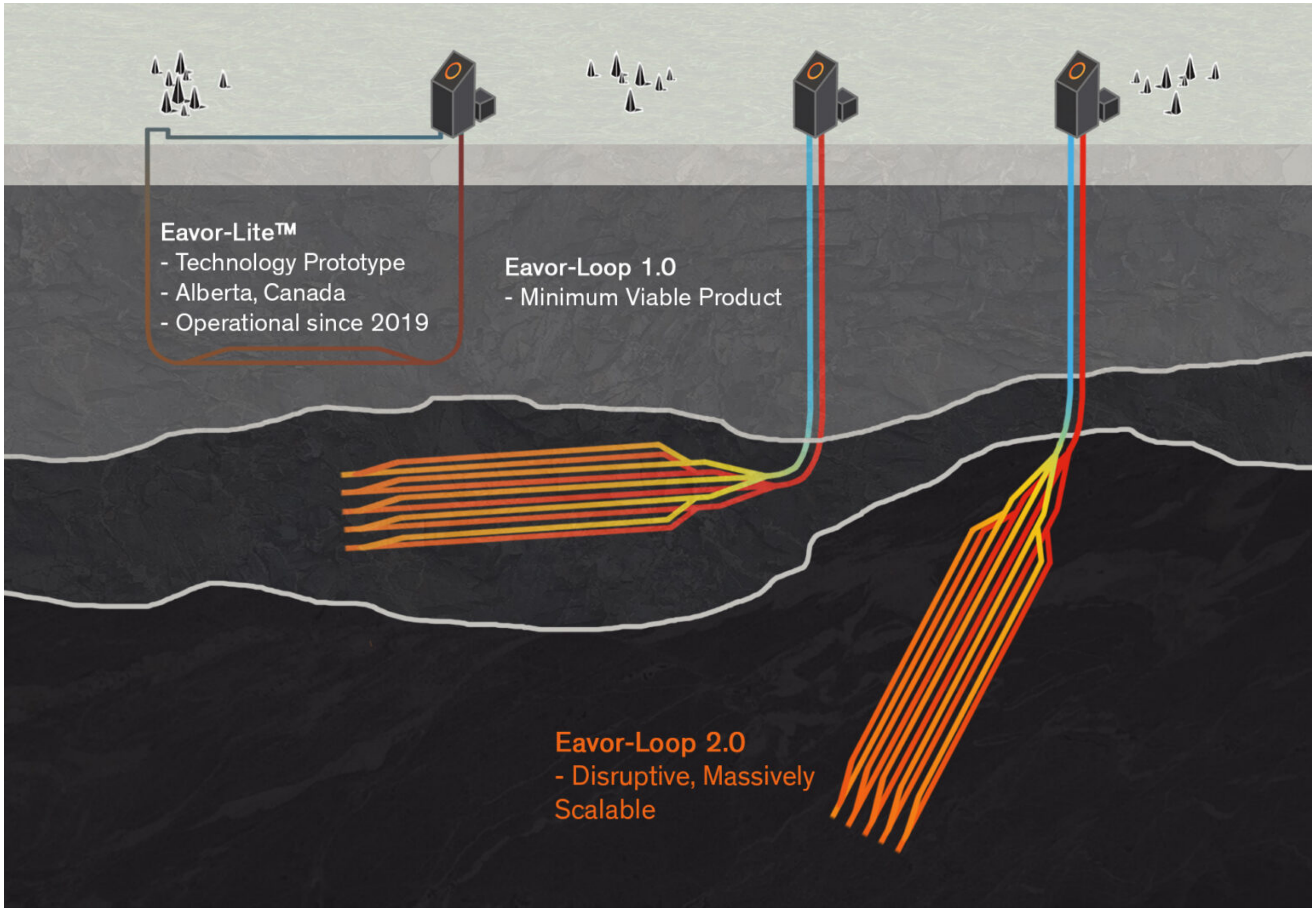
🧠 **Bottom Line:**

Closed-loop geothermal is the only realistic deep geothermal solution below 4 km.

How the Eavor Loop Works

- Closed-loop U-tube: two verticals joined by multilateral horizontals
- Working fluid circulates in sealed wellbore—no produced brine
- Natural thermosiphon delivers 150–180 °C to surface
- No fracking ➜ minimal seismic & environmental risk

What are the different kinds of Eavor-Loops?



🛠️ Comparison of Deep Drilling Technologies for Geothermal (Target: 8.5 km, 150–180 °C)

Technology	Description	Max Practical Depth	Drilling Speed	Cost/Metre	Suitable for Closed Loop?	Maturity Level	Notes
Conventional Rotary (Mud)	Standard oil & gas method using rotary drill + mud circulation	~6–7 km	🟡 Medium (~5–10 m/hr)	💰 $600–1500/m	🟡 Requires heavy casing	✅ Mature	Slows significantly at deeper depths; high casing costs at 8.5 km
Eavor/Enhanced Rotary	Closed-loop, insulated pipe + chemical seal (RockPipe™) in hard granite	✅ 8.5+ km	🟢 Fast in laterals (~12 m/hr)	💰 ~$400–800/m	✅ Yes	🟢 Emerging-Mature	Proven at 5.5 km in NM; scalability being tested in Geretsried
Coiled Tubing (CTD)	Uses continuous tubing; great for re-entry or shallow directional work	🔴 ≤3 km	🟢 Very Fast	💰 Low	🔴 Not for deep vertical	🟡 Limited	Cheap and fast, but not strong enough for deep granite drilling
Gyrotron/Plasma (Selgrade)	Uses microwave or plasma beam to vaporize rock without mechanical bit	🚀 >10–15 km (theoretical)	🟢 Very Fast (theoretical)	❓ TBD	🟢 Could be ideal	🔴 Experimental	Still in lab stage; not yet field-tested or economically modeled
Percussion (Water Hammer)	Hammers drill head with hydraulic energy; good in hard rock	🟡 ~5–6 km	🟡 Medium	💰 Variable	🟡 With custom casing	🟡 Emerging	Energy-intensive, needs robust bit design for deep closed loop
Thermal Spallation	Uses heat to break off rock flakes at surface — no bit contact	🔴 ~1–2 km so far	❓ Unknown	❓ Unknown	🔴 Not yet proven deep	🔴 Experimental	Conceptual only; promising for brittle rock but not used at depth

🛠️ Deep Geothermal Casing Materials — Cost, Longevity & Depth Suitability

Material Type	Approx. Cost (raw)	Max Decade-Stable Temp (°C)	Longevity @ 150–180 °C	Suitable for Brine/CO_2?	Yield Strength (MPa)	Max Probable Depth (km)	Notes
Carbon Steel (API P-110 / Q-125)	$0.80–1.00 / kg	~150 °C	⚠️ 5–15 years	❌ No	758–862 MPa	~3.5–4 km	Strong but corrodes fast; not viable for deep or corrosive environments
Stainless Steel 316L	$2–4 / kg	~250 °C	✅ 80–150 years	🟡 Moderate	~170–485 MPa	~3.5–5 km	Prone to pitting in chlorides; moderate strength
13Cr Steel (with coating)	$4–7 / kg	~280–300 °C	✅ 50–80 years	🟢 Good	~620 MPa	~5–6 km	Stronger than 316L; coating needed for acidic or brine-rich zones
Duplex Stainless (2205/2507)	$3–6 / kg	~250 °C	✅✅ 100–200+ years	✅ Yes	620–800 MPa	~6–7 km	Excellent strength + corrosion resistance; good value
Bimetallic (Carbon + 316L/625 liner)	~$10–20 / m lined	250–600 °C	✅✅ 100–200+ years	✅ Yes	Composite (outer 700+ MPa)	~7–8.5 km	Best for deep, hot, corrosive wells; internal alloy layer handles stress
Nickel Alloy (Inconel 625/718)	$25–40 / kg	~600–650 °C	✅✅✅ 200+ years	✅ Yes	620–1030 MPa	~8.5–10 km	Extreme conditions only; long-term resilience to temperature + pressure
Hastelloy C-276	$30–50 / kg	~500–600 °C	✅✅ 100–200+ years	✅ Best-in-class	~690 MPa	~7–8.5 km	Ultimate anti-corrosion choice; too costly for general use
Titanium Grade 2	$20–30 / kg	~350–400 °C	✅ 80–100 years	✅ Yes	~345 MPa	~3.5–4.5 km	Corrosion-proof but weaker and harder to weld than steel