What if next-generation geothermal energy enabled universal energy access?

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Next-Gen Geothermal

Within Reach | Transitional | **Visionary**

Innovative approaches to geothermal energy combined with advanced machine intelligence and materials make geothermal energy accessible, cost-effective and less dependent on location, promoting a sustainable source of renewable energy.

UNCERTAINTIES

Nature, Technology

MEGATREND (Most significant)

Pushing the Boundaries on Energy

TRENDS

Cross-Sectoral Partnerships
Net Zero
New Materials
Repurposing Assets
Transforming Energy

TECHNOLOGIES

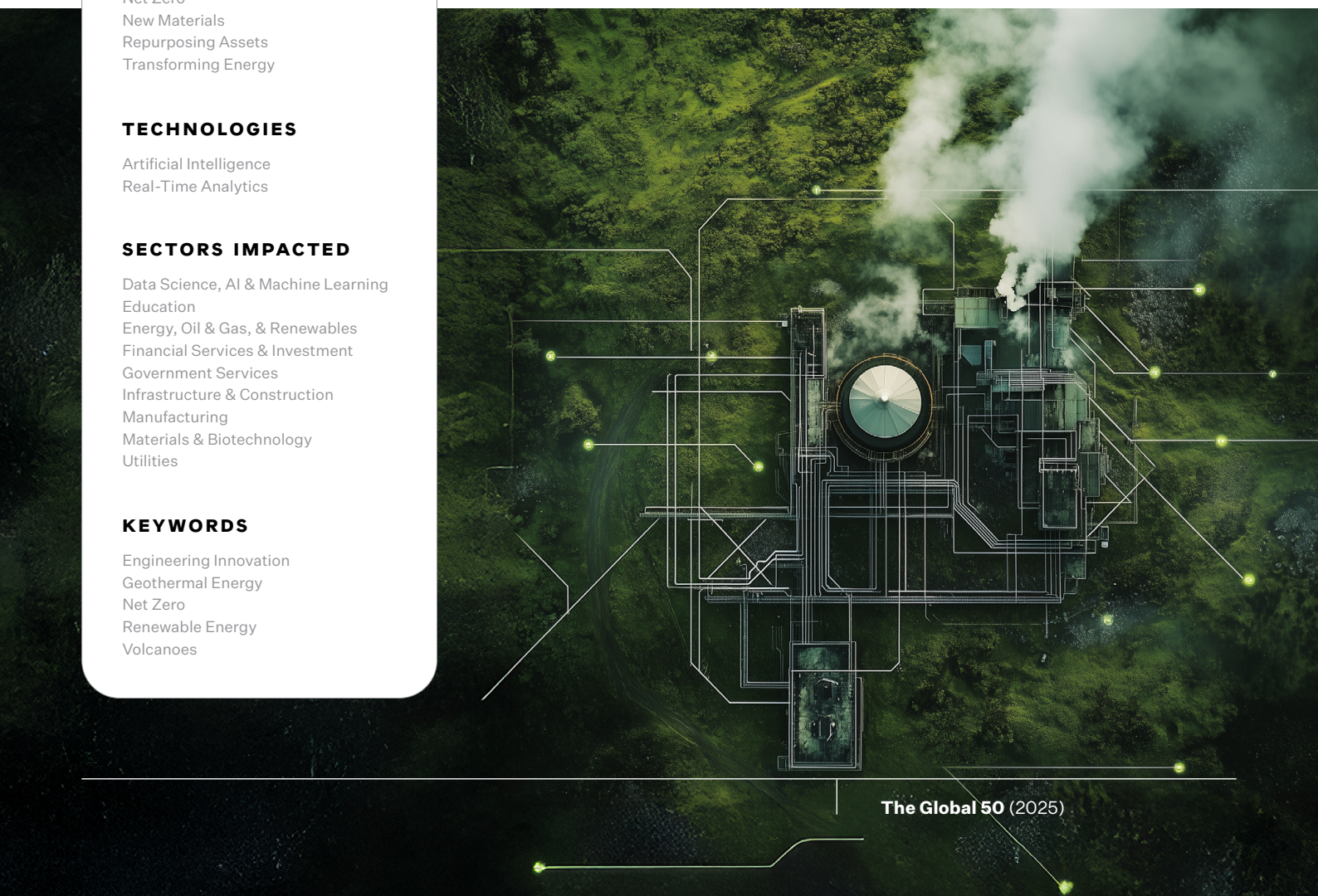
Artificial Intelligence
Real-Time Analytics

SECTORS IMPACTED

Data Science, AI & Machine Learning
Education
Energy, Oil & Gas, & Renewables
Financial Services & Investment
Government Services
Infrastructure & Construction
Manufacturing
Materials & Biotechnology
Utilities

KEYWORDS

Engineering Innovation
Geothermal Energy
Net Zero
Renewable Energy
Volcanoes



WHY IT MATTERS TODAY

With

60%

annual availability, **geothermal is the most reliable renewable energy source in the world, yet it is used the least**

With 60% annual availability, geothermal – heat from beneath the Earth's crust – is the most reliable renewable energy source in the world, yet it is used the least, lagging behind wind and solar due to limited investment and market share.[1157] Many East African countries could address energy poverty with their abundant geothermal reserves,[1158] and 15–22% of India shows high geothermal potential.[1159] Europe's geothermal energy is projected to supply 4–7% of electricity by 2050.[1160] As of 2022, 32 countries operated geothermal power plants, with a total capacity of 16,318 MW,[1161] accounting for 0.34% of worldwide electricity generation and 0.87% of clean energy production.[1162]

Traditional geothermal energy holds promise (especially for net zero) but is also a challenge. One study found that by repurposing oil wells to produce geothermal energy,[1163] carbon emissions can be reduced by 34% compared with conventional geothermal.[1164] At the same time, geothermal power would need to grow by 13% annually to meet net-zero emissions by 2050.[1165] Additionally, the capital costs of geothermal energy are high (despite the possibility of achieving over 90% savings on operations).[1166]

Moreover, traditional geothermal energy systems typically use convection methods, which requires either direct access to hot aquifers or fracking to increase the permeability of rock. While aquifers can be difficult to locate, fracking may induce seismic activity,[1167] limiting the possible locations for geothermal energy. The United States leads global production (followed by Indonesia, the Philippines, and Türkiye), and geothermal energy supplies over 30% of electricity in Iceland and 45% in Kenya.[1168]

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THE OPPORTUNITY

BENEFITS

Scalable renewable energy; progress towards the Sustainable Development Goals; valuable by-products.

RISKS

High implementation costs; failure of materials in high heat conditions; unintended triggering of earthquakes.

Geothermal energy is not new, but innovative technologies, materials, and advanced machine intelligence make access to geothermal energy easier, less costly and not limited to any specific location.[1169,1170] Examples of approaches include using nuclear fusion for deeper and easier drilling to access thermal energy at depths of 20 km;[1171,1172] employing conduction, turning cold water into steam using hot rock instead of using aquifers or fracking;[1173,1174] repurposing decommissioned onshore oil rigs;[1175] and using magma's superheated steam to produce 10 times more energy than conventional geothermal wells.[1176]

Advanced materials, such as nickel–titanium alloys, can handle extreme heat[1177] and solid materials such as sand and ceramics address artificially created fractures in enhanced geothermal systems.[1178] Advanced machine intelligence can accelerate the development of next-generation geothermal energy by enhancing system design, including geothermal energy storage,[1179] optimising performance, and improving fault detection, particularly when coupled with real-time data.[1180] Geothermal energy can be integrated into energy grids and underground thermal storage systems and has hybrid applications with economically valuable by-products, such as boric acid[1181] and hydrogen.[1182]

Geothermal energy is not new and innovation may make access easier, less costly and not limited to any specific location