



ENERGY

GEOTHERMAL

CHALLENGES IN IMPLEMENTATION

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What are the challenges and limitations of current technologies to implementation of geothermal energy?

While geothermal energy boasts immense potential as a clean and renewable power source, several challenges and limitations exist to expanding current implementations:

- **Location Dependence:** Geothermal resources are unevenly distributed, concentrated in areas with hot springs, volcanic activity, or specific geological formations. This limits accessibility for many regions, hindering widespread adoption.
- **High Upfront Costs:** Drilling deep wells, establishing infrastructure, and managing fluid circulation are expensive endeavors. This can be a deterrent to investors, especially compared to readily available fossil fuels with established infrastructure.
- **Technical Limitations with Lower Temperatures:** Current technologies efficiently convert geothermal energy to electricity at higher temperatures (above 80°C). However, vast untapped resources exist at lower temperatures. Extracting energy from these sources economically remains a challenge.
- **Environmental Concerns:** Geothermal power plants can emit greenhouse gases and harmful minerals like hydrogen sulfide, requiring careful management and mitigation strategies. Additionally, reinjecting used fluids back underground requires proper monitoring to prevent contamination of aquifers.
- **Seismic Activity:** Enhanced Geothermal Systems (EGS) can trigger earthquakes in some areas, raising safety and public acceptance concerns. Strict regulations and monitoring are crucial to managing these risks.
- **Limited Data and Exploration:** Identifying and characterizing geothermal resources can be complex and expensive. Developing better exploration techniques and improving data availability is crucial for optimal resource utilization.
- **Social and Political Obstacles:** Local communities may have concerns regarding environmental impacts, land use, and noise pollution. Addressing these concerns and fostering community engagement is critical to project success.




Overcoming the Complexity

Despite these challenges, ongoing research and development are addressing these limitations:

- **Enhanced Geothermal Systems** (EGS) are being developed to access lower-temperature resources.
 - A recent [research paper](#) proposes an EGS which injects surface water into natural reservoirs, improving those natural reservoirs and creating artificial reservoirs while extracting heat from supercritical geothermal resources.
- **AI, ML and IoT technologies** are accelerating the development of geothermal energy.
 - In this chapter, AI-powered IoT facilitates various stages of geothermal power processing; starting from the identification of geothermal field for the installation of power plants, through optimization of geothermal operations and the removal of geothermal waste.
- **Electromagnetic** (EM) technology aims to identify subsurface sources of geothermal heat prior to drilling, providing a low-cost pre-drilling temperature estimation.
 - In this paper, the authors propose a method to locate subsurface sources of geothermal heat prior to drilling using electromagnetic (EM) technology, which can provide a proxy for temperature measurement without physical drilling into the Earth's crust.
- New technologies like **Organic Rankine Cycles** (ORCs) offer improved geothermal efficiency at lower temperatures.
 - [Recent research](#) has also shown that a small ORC system used in full or partial evaporation mode offers a higher utilization of the heat source.

While these advancements are significant, the need for further research and development of technologies that can overcome the challenges of implementing geothermal energy solutions more broadly remains.



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