Editorial

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Geothermal energy: An untapped potential in the clean energy transition

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Introduction

The topic of clean energies and decarbonization has recently been addressed by many governments worldwide. Electric vehicles and solar panels are promoted in many regions as a temporary solution, despite their high mineral consumption. As of 2021, in the state of Florida, 73.9% of electricity came from natural gas and 8% from coal and oil. Similarly, in Texas, 47.4% of electricity was from natural gas and 18.6% from coal, making the environmental benefits of electric cars in these regions questionable.

Regarding the role of critical minerals in the transition to clean energy, the EIA (Energy Information Administration) states that a clean energy system differs significantly from one powered by traditional hydrocarbon resources. Solar photovoltaic plants, wind farms, and electric vehicles typically require more minerals for their construction compared to their fossil fuel counterparts. A typical electric car takes 7 years of use to offset its environmental debt incurred during its manufacturing process, requiring six times the mineral inputs of a conventional car. A land-based wind turbine requires nine times more mineral resources than a gas-fired plant. Since 2010, the average amount of minerals needed for new energy generation capacity has increased by 50%, correlating with the rise in renewable energy investments. The specific minerals vary by technology; lithium, nickel, cobalt, manganese, and graphite are crucial for battery performance, longevity, and energy density, while rare earth elements are essential for permanent magnets in wind turbines and electric vehicle motors. Copper and aluminum are vital for electrical grids, with copper being fundamental across all electricity-related technologies.

Considering Petroleum Engineering's close relationship with geothermal reservoir exploitation, it is worth focusing on this source of clean and renewable energy for electricity production. Geothermal energy is the Earth's most abundant energy source, capable of meeting all humanity's energy needs for generations to come. Continuously, the Earth generates approximately 46.6 TW of thermal power through the radioactive decay of heavy nuclei like ^{238}U, ^{232}Th, and ^{40}K within the crust and mantle. This energy occasionally manifests on the surface through seismic and volcanic activities along tectonic plate boundaries. The Earth also stores a vast amount of thermal energy (heat content) estimated around 12.6×1024 MJ, with 5.4×1021 MJ (equivalent to 1.5×1012 TW h) residing in the Earth's crust. Given that global energy consumption in 2012 totaled 154,795 TW h, geothermal energy could effectively meet humanity's energy needs for several decades.

However, developing geothermal energy is highly challenging and requires significant initial investment. The development process begins with understanding the geothermal system type to identify utilization possibilities and ensure commercial viability. Geothermal development involves not only using efficient equipment but also adapting geothermal resources to reliable, proven technologies. Wells serve as the arteries of geothermal energy development, providing access to fluid carrying thermal energy and crucial data about the reservoir. Yet, well testing and analysis remain the least understood and studied aspects of geothermal systems by most researchers in the field.

Moreover, the technology required to harness geothermal energy faces numerous technical and commercial challenges. The primary hurdle is the high cost and commercial risks associated with drilling deep geothermal wells for energy production. Geothermal projects only become financially viable after drilling and testing large, deep wells, and quantifying their energy output potential. The performance of geothermal wells can also change over time; typically, production from production wells declines, necessitating additional drilling. Injection wells may also experience reduced capacity, requiring intervention. Well testing helps identify reasons for well behavior changes and guides reservoir engineers toward potential solutions or interventions.

In conclusion, while the transition to clean energy presents significant challenges, exploring diverse sources like geothermal energy alongside improving technologies and mineral resource management will be critical to achieving sustainable energy goals globally.

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Conflicts of interest

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