Strong geothermal potential

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A joint project which saw two boreholes drilled in northern Singapore has revealed subsurface temperatures reaching up to 122°C at a depth of 1.76 km in Sembawang, significantly higher than earlier findings recorded in Admiralty, where 70°C was measured at a depth of 1.12 km.

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Conducted by scientists from NTU Singapore and TUMCREATE, in collaboration with Surbana Jurong, the updated findings strongly suggest that the northern region of Singapore is a promising site for further geothermal exploration.

The results were shared at a recent public symposium titled "Geothermal energy is just beneath our feet, how do we unlock it?" organized by the joint research team.

The symposium brought together global experts, including representatives from the Technical University of Munich (TUM), International Energy Agency (IEA), the European Geothermal Energy Council (EGEC), the Ministry of Energy and Mineral Resources (Indonesia), the European Technology & Innovation Platform—Geothermal (ETIP), to discuss how countries, industry and academia can collaborate to unlock geothermal potential in urban environments such as Singapore.

The joint research team, led by Professor Alessandro Romagnoli from the Energy Research Institute @ NTU (ERI@N) and Dr. Tobias Massier from TUMCREATE, assessed Singapore's landscape to determine the feasibility of tapping into geothermal energy—a weather-independent clean energy source.

Based on rock core analysis and temperature gradients, the researchers found that heat flow at the northern part of Singapore has been evaluated to be at least twice the global continental average, even though Singapore is not located in a volcanic region.

"With a measured temperature of 122°C at 1.76 km, the Sembawang borehole provides a new reference for geothermal assessments in Singapore," said Prof Romagnoli, Cluster Director, Multi-Energy Systems & Grids, ERI@N.

"The results mean that we have strong potential for electricity generation and district cooling using commercially available technologies in the geothermal energy sector. The unique combination of elevated heat gradients and high heat-producing granites offers us compelling reasons to pursue further mapping of the northern subsurface."

The current data will contribute to ongoing geothermal feasibility studies, such as those conducted by firms like Surbana Jurong, which aim to assess how far the geothermal reservoir extends, how long it can remain viable, and what types of technologies are suitable for Singapore's intended applications.

For instance, if the temperature gradient remains unchanged, there is the potential for temperatures to reach 230°C at depths of 5 km.

Known geothermal applications for the recorded temperature range include electricity generation, district cooling, industrial heating and thermal-driven desalination.

Technologies to harness geothermal potential

Heat extraction technologies such as Advanced Geothermal Systems (AGS) and Enhanced Geothermal Systems (EGS), are currently being assessed in Singapore as part of national efforts to evaluate geothermal energy's role in supporting the Republic's goal of achieving net-zero emissions by 2050.

Presenting at the symposium was Canadian start-up Eavor, which is backed by Singapore investment company Temasek. Eavor's technology is a type of closed-loop deep geothermal system (AGS) that harnesses heat from hot dry rocks located several kilometers underground.

GreenTherma, a Norwegian start-up that also participated in the symposium, described their technology as a modular closed-loop geothermal system (AGS), which leverages the versatility of geothermal energy to generate non-electrical outputs, such as direct-use heating and cooling.

Both AGS and EGS approaches differ from traditional geothermal systems, which rely on naturally occurring shallow reservoirs of hot water or steam—geological features that are absent in Singapore.

A comprehensive techno-economic and environmental analysis was also carried out by the joint research team on both AGS and EGS.

The researchers modeled and simulated their application in electricity generation and chilled water production used in Singapore's district cooling systems and data centers.

Compared to current energy prices and chilled water tariffs, both systems demonstrated cost-saving potential:

- In the AGS simulation, the electricity generation cost was comparable to hydrogen gas-fired power plants, while chilled water costs were lower by at least 28%.
- In the EGS simulation, electricity generation costs were reduced by at least 38%, and chilled water costs by 39%.

In addition to cost savings, both systems showed a reduction in greenhouse gas emissions by at least 90%.

If deployed, such geothermal technologies could help Singapore meet part of its long-term energy needs and significantly reduce its reliance on carbon-based fuels, the team added.

The NTU team is also contributing expertise to regional partnerships, such as with Indonesia, to support geothermal development across Southeast Asia.

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