Study identifies potential for geothermal energy to become a key renewable resource in Singapore

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Core samples of the Simpang granite from various depths from 100m to 1.1km taken from the slim hole at Admiralty Lane. Credit: Nanyang Technological University

Researchers from Nanyang Technological University, Singapore (NTU Singapore) and TUMCREATE, the Technical University of Munich's (TUM) multidisciplinary research platform located in Singapore, in collaboration with Surbana Jurong, have found that Singapore has a significant geothermal resource that could be a consistent source of clean energy in addition to solar power.

These findings were from their study that explores the geothermal potential in Singapore.

As part of this study, a joint research team led by NTU Associate Professor Alessandro Romagnoli, Co-Director of the Surbana Jurong-NTU Corporate Laboratory, and TUMCREATE Principal Scientist Tobias Massier, drilled an exploratory slim hole to 1.1 kilometers below ground at Admiralty Lane.

The location is close to the Sembawang hot spring, and the drilling pulled up rock core samples of the underlying rock formation, known as the Simpang granite. The granite is named after Simpang, an urban planning area located in the middle part of Singapore, where the Admiralty drilling site and the Sembawang hot spring are located.

While all rocks contain some heat-generating elements, some have a higher concentration of these elements, thus producing more heat than others. As part of the study, the team measured the rock temperatures at different depths in addition to the drilling.

Based on the collected samples and data extrapolation, the team estimates that the geothermal site at Admiralty Lane could have a temperature of some 200°C at depths of four to five kilometers and deeper.

Currently, the average temperature of the Simpang granite found at a depth of 1.1 kilometers at Admiralty Lane is already hot enough to cook a soft-boiled egg—which is hotter than rock temperatures found at that depth in many other non-volcanic regions.

Examples of applications at lower temperatures can be used for recreational heating (30 to 60°C), food processing and water desalination (60 to 90°C), fabric dyeing (90 to 120°C), while higher temperatures can be used for district cooling (above 90°C), pulp and paper processing, cement drying (120 to 150°C), electricity and hydrogen generation (above 150°C).

Given that most granite has heat-producing elements and is capable of storing and transferring heat (known as heat flows), the team discovered that the Simpang granite at Admiralty Lane also has high heat flows, twice as much as the global average, excluding those found in conventional geothermal areas in the vicinity of volcanos.

NTU Vice President (Industry) Professor Lam Khin Yong, said the exploratory study is in line with both NTU's and Singapore's push towards renewable energy research and its promising findings could lead to a new renewable energy resource that many never thought possible.

"The findings of having a heat-generating granite below northern Singapore holds great potential in our quest for more renewable energy sources for the nation. In line with the NTU 2025 Strategic Plan and our Sustainability Manifesto, we will continue to explore, research and create new knowledge that allows us develop solutions and applications that will benefit society," said Prof Lam.

"With more research and development into new emerging technologies, such as heat pipes to draw heat energy for energy generation and cooling purposes, we can potentially unlock a low-carbon energy source that is constant regardless of weather conditions—unlike solar—and abundant, possibly lasting decades."

Mr. Ralph Foong, deputy chief executive (energy planning and development), EMA, added, "The findings from NTU's study are a useful basis for us to better understand the potential for geothermal energy to become a key renewable resource for Singapore. If proven viable, geothermal energy could contribute to a more sustainable and diversified energy mix. We look forward to collaborating with NTU and other stakeholders to fully assess Singapore's geothermal potential."

Lead scientist of the study, Assoc Prof Romagnoli, said the data collected suggests the presence of relatively higher temperatures compared to other deep boreholes worldwide.

"This unique characteristic of having a higher temperature gradient, combined with the high heat production of the Simpang granite, contributes to the unusual high heat flow," said Assoc Prof Romagnoli, who is also the Cluster Director of Multi-Energy Systems & Grids at the Energy Research Institute @ NTU (ERI@N).

Lead scientist Dr. Tobias Massier from TUMCREATE pointed out the possible utilization of Singapore's geothermal power potential to cover the country's cooling demand.

"Every gigawatt of geothermal power could cover about 12% of Singapore's current cooling demand, which sounds quite exciting. We are currently researching on the utilization of geothermal energy to augment Singapore's energy mix. This is also part of TUMCREATE's contribution towards achieving Singapore's national climate target of net zero emissions by 2050," Dr. Massier stated.

The study involved multiple scientists, including Associate Professor Zhao Zhiye, Interim Director, Nanyang Center for Underground Space at NTU, Associate Professor Wu Wei, NTU School of Civil and Environmental Engineering, Dr. Mark Lim Jian Wei, Energy Research Institute @ NTU.

Mr. Tan Wooi Leong, managing director, energy and industrial, Surbana Jurong, said, "Geothermal energy will add to Singapore's renewable energy mix to support the energy needs of industrial and residential sectors in Singapore. This enhances Singapore's energy security and is a step closer to bringing down the cost of energy for businesses and consumers. These initial findings are very encouraging. Surbana Jurong will continue to pursue further studies to unlock the full potential of geothermal energy and deliver practical applications of this valuable resource."

Using Fourier's law of thermal conductivity, the team estimates that the Simpang granite at Admiralty Lane has twice the global continental average of heat flows, in line with previous estimates obtained from regional heat flow maps conducted by other studies.

They also found the presence of potential porosity for underground storage within the fractured rocks at around one kilometer deep, which opens possibilities for underground thermal storage applications—where heat is pumped and stored in an underground space until it is needed, or for other purposes like an underground rock cavern or carbon dioxide sequestration.

The study has shed new light on Singapore's geothermal landscape and the team has shared their findings in detail with EMA.

The team recommends further investigation, such as geophysical surveys and drilling to five kilometers deep. This will provide more data to evaluate the total amount of heat stored in Singapore's deep subsurface rock, the speed of heat transfer, the amount of energy generation it may support, and more.

Provided by Nanyang Technological University

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