



Promotion Strategy for Geothermal Energy and Green Finance

Geothermal Energy is a Stable and Sustainable Source of Green Energy that will be Essential in Achieving Net-Zero Emissions.

Background

The various environmental issues created by global warming have made developing clean and renewable energy as well as reducing carbon dioxide emissions some of the most pressing challenges for governments around the world. Advanced countries have been actively developing geothermal energy, which they regard as a vital source of green energy. Geothermal energy, unlike highly weather-dependent wind and solar energy, is a baseload energy source located beneath the Earth's surface that can provide electricity year-round at all times of the day, barring equipment malfunctions. With a higher power generation efficiency compared to solar and wind energy, geothermal energy has a diverse array of applications and can complement energy storage systems. Thus, geothermal energy is an ideal technology for lowering carbon emissions and reducing reliance on fossil fuels.

Taiwan, which is located along the Pacific Ring of Fire, has a relative abundance of geothermal resources because of active tectonic and volcanic activity underneath the country. Taiwan aims to achieve a geothermal installation capacity of 20 MW by 2025, 1.2 GW by 2030, and 6 GW by 2050. Primary development strategies include identifying potential geothermal zones, expanding drilling capacity in the short term, and creating comprehensive strategies for emerging next-generation heat extraction technologies in the long term.

Global Outlook and Domestic Progress

Geothermal energy is playing an increasingly important role in global energy transition. Governments and businesses worldwide are achieving sustainable development goals by actively investing in resources that promote innovation and application of geothermal power generation technology. Geothermal power projects typically require significant upfront capital, particularly during their initial stages such as exploration and drilling. Therefore, many countries aim to encourage private sector participation in geothermal development by reducing risk through extensive policies and support measures. This includes enacting specialized legislation, relaxing regulations, introducing financial instruments,

providing funding and subsidies, and offering tax incentives. Guiding capital and facilitating investment will create a virtuous cycle of the private sector seeking out opportunities in sustainable green development.

According to statistics from the Energy Administration, Ministry of Economic Affairs (MOEAEA), as of 2023, thermal power accounted for 83.14% of Taiwan's total electricity generation, while geothermal power made up only 0.01%. However, Taiwan has significant potential to develop geothermal energy due to its unique geographical location and natural advantages. Therefore, the Taiwanese government has gradually introduced

policies to encourage geothermal development in recent years. For instance, in 2022, the Ministry of Economic Affairs (MOEA) established the “Geothermal One-Stop Service Office” to simplify development processes and coordinate cross-agency regulations. Additionally, “Regulations for Geothermal Exploration and Development Permits and Management” were issued to provide a more robust legal framework to developers and further clarify the standards and procedures for geothermal development. Furthermore, the Central Geological Survey is currently conducting geothermal exploration in 10 potential geothermal zones and has established the Geothermal Exploration System. This platform helps mitigate the risks of early-stage exploration by publicly sharing the results of surveys and analysis related to geothermal resource distribution.

In addition, state-owned enterprises, such as CPC Corporation (CPC) and Taiwan Power Company (Taipower), are leading the development of deep geothermal energy in Taiwan. CPC has sought out partnerships with leading multinationals to leverage their advanced deep geothermal technology. By the end of 2024, CPC plans to establish a 25 MW large-scale deep geothermal demonstration project by drilling Taiwan's first 4-kilometer-deep well in Yuanshan, Yilan. In the future, Taipower will conduct deep geothermal exploration in Datun Mountain with internationally renowned geothermal developers and technical service providers. Subsequently, Taipower will use the results of such exploration to evaluate the feasibility of future development and power plant construction.

In terms of academic and research institutions, Academia Sinica serves as Taiwan's key academic

advisor on geothermal energy by focusing on areas such as geophysical surveying and geochemical analysis. Academia Sinica will also partner with CPC to conduct 4-to-5-kilometer-deep geothermal exploration in Yuanshan, Yilan. The Industrial Technology Research Institute (ITRI) possesses Taiwan's leading geophysical exploration technology and assists in surveying key potential geothermal zones. ITRI also has experience in implementing the Ministry of Economic Affairs' Geothermal Energy Technology Research and Development Program. Universities such as National Taiwan University, National Central University, and National Cheng Kung University are engaged in various research areas, including geophysical surveying, geological analysis and investigation, geological modeling, environmental impact and risk assessments, production simulation, and economic analysis.

In terms of financial support, the Incentive Regulations for Geothermal Energy Demonstration have created more appealing financing for geothermal development by establishing an insurance and interest-free loan mechanism for drilling that covers losses of up to 50%. Additionally, banks have begun providing financing for geothermal power plant equipment. For example, Bank SinoPac provided exclusive financing for the construction of a geothermal power plant in Jinlun, Taimali Township, Taitung County. Similarly, Land Bank of Taiwan has provided NT\$720 million in financing to Fabulous Power Co., Ltd. to fund the development and operation of the New Taipei City Sulfur Valley Geothermal Power Demonstration Zone. Throughout Taiwan, financial institutions' investment support have further reduced barriers to geothermal development.

Strategic Planning Framework

As a stable baseload power source, geothermal energy will play a critical role in Taiwan's green transition. By reviewing Taiwan's geothermal development potential and current support for policy while drawing from the successful experiences of various countries—such as Indonesia's regulatory framework, Japan's government guarantees, and Turkey's feed-in tariff system and equipment subsidies—it is clear that effective policy and innovative financial mechanisms are essential in driving the development of geothermal power.

Strategy 1: Investment in Geothermal Energy Exploration and R&D on Foresight Engineering Technology

Refer to the approaches of Japan and Turkey, in which

the government assumes a greater portion of early-stage exploration risks. The Ministry of Economic Affairs Geological Survey and Mining Management Agency has designated geothermal surveys as a long-term priority and is responsible for coordinating nationwide investigations of potential geothermal zones. In the future, relevant agencies can partner with CPC due to the company's extensive experiences in drilling oil wells. In addition, sharing newly accumulated geological data from drilling with developers can significantly reduce the risks of early-stage exploration.

In terms of technology, it is essential to keep investing in the R&D of advanced deep geothermal power generation technologies. This includes Advanced Geothermal

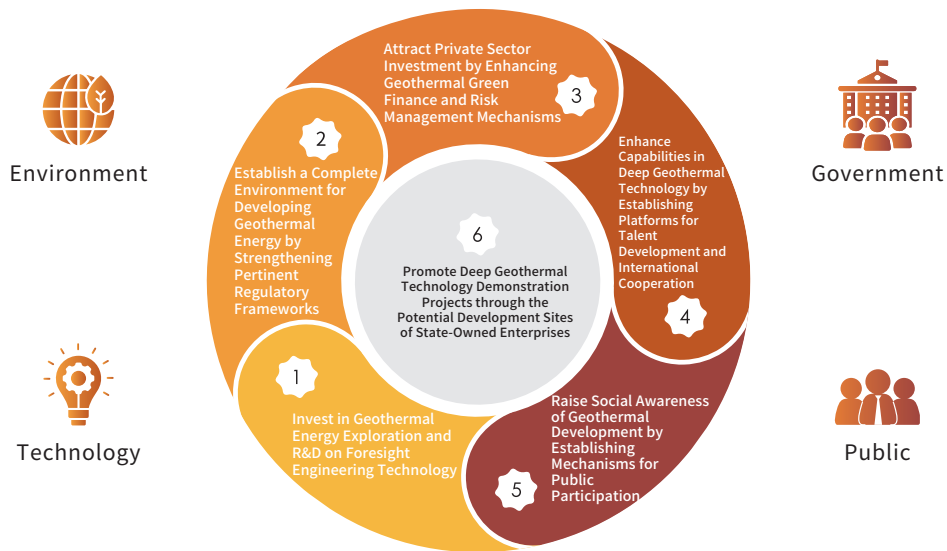


Figure 1 Comprehensive Strategic Planning for Promoting Geothermal Technology and Green Finance in Taiwan

Source: Taiwan Science and Technology Office for Net-zero Emission (T-STONE) (2024).

Systems (AGS), Enhanced Geothermal Systems (EGS), Supercritical Geothermal Systems (SGS), high-efficiency exploration technologies, reservoir engineering and management, as well as scientific research projects. Furthermore, a certain proportion of these technologies must be practically implemented within geothermal development zones.

Strategy 2: Establish a Complete Environment for Developing Geothermal Energy by Strengthening Pertinent Regulatory Frameworks

The various stages of geothermal energy development touch upon issues such as hot spring exploration and utilization, indigenous land rights, soil and water conservation, environmental ecology, and power plant construction. Currently, administrative agencies regulate these areas based on their respective jurisdiction and responsibilities. To address bottlenecks in geothermal development, the government has been proactively adjusting pertinent regulations. For example, the geothermal chapter of the Renewable Energy Development Act specifies the application and review procedures for exploration, development, and operational phases of geothermal projects. Even though the central government manages and reviews relevant permits in conjunction with local governments, geothermal development in Taiwan must still overcome many regulatory barriers in terms of issues such as land rights and environmental assessments.

Strategy 3: Attract Private Sector Investment by Enhancing Geothermal Green Finance and Risk Management Mechanisms

Financial institutions face several challenges in terms

of investment and financing for geothermal projects such as the high and unpredictable costs of early-stage exploration and drilling as well as disproportionate risks and returns, a lack of domestic developers with experience in construction and commercial operations, and the relatively nascent status of geothermal energy in Taiwan's renewable energy landscape. Compared to wind and solar energy, geothermal energy has lower feed-in tariffs and is underdeveloped in terms of policy support, administrative processes, market maturity, and industrial infrastructure. Facilitating institutional investment will also be a critical factor in advancing geothermal power generation.

Developing deep geothermal power is both costly and risky. Therefore, it is unlikely to enter the free market for renewable energy in the short term. Thus, the government should consider establishing a geothermal development fund. This fund could grow in scale through returns from successful geothermal development projects, which in turn would support subsequent early-stage exploration and development activities. By reducing development risks and costs, this approach would ensure sustainable, GW-scale development of Taiwan's geothermal industry.

In the future, the Ministry of Economic Affairs should partner with relevant agencies to provide information such as geothermal resource location and technology risk assessment to assist the Financial Supervisory Commission in formulating more comprehensive practices and norms for identifying geothermal technology R&D investment and financing. This would accelerate the process of investment and financing by supporting financial institutions in conducting subsequent evaluations.

Strategy 4: Enhance Capabilities in Deep Geothermal Technology by Establishing Platforms for Talent Development and International Cooperation

The development of geothermal power generation involves several stages such as resource exploration and evaluation, drilling verification and production, power plant development and operation, and environmental resource management. These stages require the assistance of professionals with expertise in local geothermal geological structures, a skillset that is difficult to source internationally. As such, initial development is challenging, high-risk, and highly dependent on local experts. Therefore, developing Taiwan's geothermal power generation industry depends upon cultivating domestic talent with relevant practical experience.

Strategy 5: Raise Social Awareness of Geothermal Development by Establishing Mechanisms for Public Participation

Applications for geothermal exploration and development involving indigenous land, villages, or surrounding areas must, in accordance with the regulations of The Indigenous Peoples Basic Law, undergo consultation and obtain consent prior to submission. Indigenous peoples are entitled to a portion of the benefits of geothermal projects. Taiwan could consider emulating New Zealand's approach of collaborating with the Māori community to actively encourage the private sector development of geothermal energy. In New Zealand, the

government helped the Māori community establish trust companies to facilitate communication. In addition to ensuring environmental protection while addressing the needs of local residents, this approach also facilitated the sharing of benefits created by geothermal development. Designing mechanisms to strengthen citizen participation can effectively enhance the social awareness of geothermal development.

Strategy 6: Promote Deep Geothermal Technology Demonstration Projects through the Potential Development Sites of State-Owned Enterprises

State-Owned enterprises, such as CPC and Taipower, are leading the development of deep geothermal energy in Taiwan. In addition to partnering with leading multinationals in geothermal energy to leverage their advanced deep geothermal technologies, CPC also plans to drill Taiwan's first 4-kilometer-deep well in Yuanshan, Yilan by the end of 2024. The goal of this project is to establish a large-scale 25-MW-deep geothermal demonstration site. In addition, Taipower is conducting geothermal exploration in Datun Mountain and plans to conduct joint exploration with internationally renowned geothermal developers and technical service providers. Subsequently, Taipower will use the results of such exploration to evaluate the feasibility of future development and power plant construction.

Potential Benefits

As a stable baseload power source, geothermal energy can generate electricity uninterrupted year-round while reducing Taiwan's reliance on fossil fuels and enhancing its energy self-sufficiency. Geothermal power also aligns with Taiwan's policy goals of net-zero transition and promoting sustainable development. In addition, introducing green financial instruments can direct capital into the geothermal industry, scale up the sector, and foster growth in the green economy. Partnering with established international developers to draw on experience and technology from abroad can make geothermal energy a critical cornerstone in Taiwan's green transition by enhancing the maturity and efficiency of the country's geothermal development.

References

- [1] Lin, Tzu-Keng (2018). Geothermal Power Generation: The Advantages of Developing Geothermal Energy in Taiwan. Science Panorama.
- [2] Kao, Ming-Chih, Tsai, Yueh-Hsun, Weng, Min-Hang, Sung, Shu-Fan, & Chen, Chien-Chang (September, 2013). Introduction to Renewable Energy Policies and Laws. p. 237. Yuanzhao Publishing.
- [3] Geothermal Power One-Stop Service Office. <https://www.geothermal-taiwan.org.tw/>
- [4] Japan JOGMEC Geothermal Development Promotion Strategy. <https://www.jogmec.go.jp/geothermal/index.html>
- [5] EnergyOMNI, <https://www.energy-omni.com/product/detail/AT005005>
- [6] Pambudi, N. A., & Ulfa, D. K. (2024). The Geothermal Energy Landscape in Indonesia: A Comprehensive 2023 Update on Power Generation, Policies, Risks, Phase and the Role of Education. Renewable and Sustainable Energy Reviews, 189. <https://www.sciencedirect.com/science/article/abs/pii/S1364032123008663?via%3Dihub>
- [7] Taiwan Economic Journal (TEJ). Net-Zero Carbon Transition is Trending! Can Geothermal Energy Become a Major Power Source in Taiwan? <https://www.tejwin.com/insight/%e5%9c%b0%e7%86%b1%e7%99%bc%e5%b1%95%e8%b6%a8%e5%8b%a2/>