Proceedings World Geothermal Congress 2026, Calgary, Canada, June 8—11, 2026

How Geothermal Can be Beneficial for Sustainable Development in Taiwan

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I. INTRODUCTION

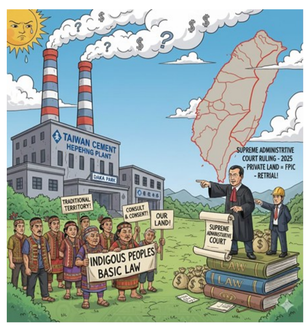
Sustainable Energy Needs: Taiwan's island geography inherently limits geological resource development creating ongoing tensions between economic growth and environmental conservation. Following global climate initiatives and the adoption of the UN Sustainable Development Goals, Taiwan announced its "Pathway to Net-Zero Emissions by 2050" in 2022. This comprehensive strategy aims to generate cleaner energy, including geothermal, by replacing fossil fuels with a sustainable development blueprint.

UN-SDGs Fit: The United Nations (UN) established the Sustainable Development Goals (SDGs) in 2016 to promote human prosperity and improved living standards in a safe and balanced manner. Within this framework, affordable, reliable, and clean energy (SDG 7) serves as a critical pillar connecting social progress to environmental stewardship (SDGs 8, 9, 11, and 13).

The Challenges: While geothermal energy aligns strongly with these goals by providing environmental, economic, and social benefits, significant challenges persist for indigenous and environmental communities. These tensions often stem from historical disputes between local populations and the government regarding land rights and resource management.

III. CHALLENGES & RESOLUTIONS

The Social and Environmental Incidents: The accelerated industrialization of Taiwan, particularly during the so called "Economic Miracle" period (1960s-1980s), led to several catastrophic environmental pollution events. These incidents were critical because they exposed the human cost of unregulated development and were the primary catalysts for the awareness of the organized environmental movement.





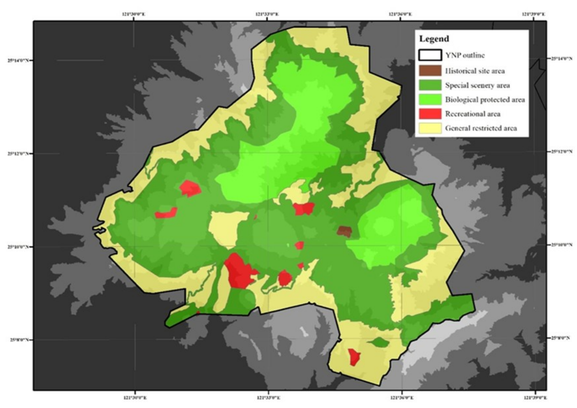


Figures 6/7/8: from left to right, 6. The legal dispute between Industrial project on indigenous land; 7. RCA waste pollution scandal in 1994; 8. The gas pipeline explosions accident in Kaoxiong City, 2013.

Restrictions in Current Laws: The rise of Taiwan's environmental movement deeply intertwined with rapid economic development and the transition from authoritarian rule to democracy, materialized legislative changes that strengthened protections for the environmental and historically disadvantaged groups.

The National Park Law, passed in 1972, imposes strict limits on resource extraction, unique landscape, and natural life protections. However, the zoning system allows a leeway in making certain land-use adjustments in the general restricted and recreational areas.

Article 21 of Indigenous Peoples Basic Law, guarantees the right to informed consent over all economic activities (Free, Prior, and Informed Consent, FPIC) for the affected communities. The remedies for a win-win communication would be early engagement with joint committees, informed/transparent/impactful consent with accessible data, and shared benefits of equity partnership and prioritized use for local economic.





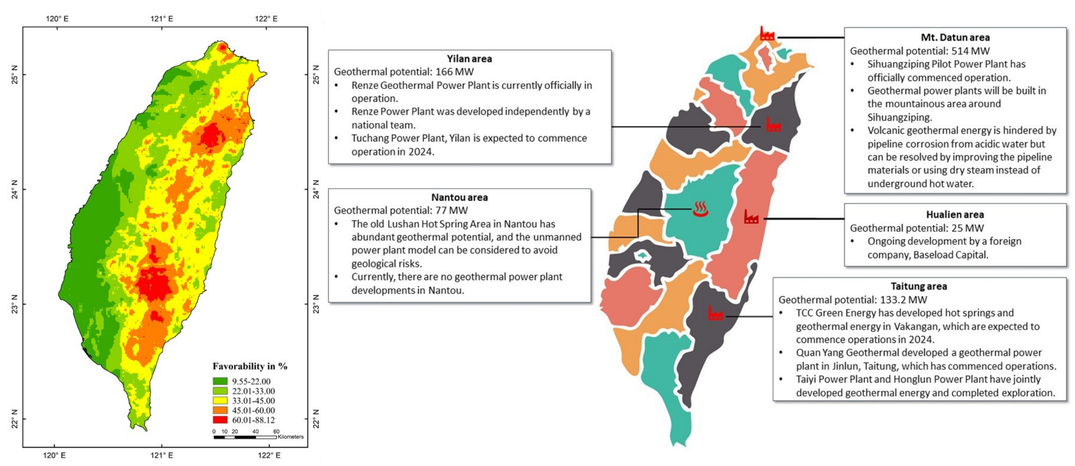
Figures 9/10: from left to right, 9. The national park zoning system provides flexibility for land-use adjustments; 10. Remedies to get consent right for development activities at the indigenous lands.

Geothermal + Socio-Environmental: Sustainable development should harmonize environmental protection with economic growth, and geothermal energy exemplifies this synergy by demonstrating how to balance economic development with conservation through versatile applications beyond traditional electricity generation. By integrating sustainable elements into science and social education, learning from global examples, and taking lessons from the past wrongdoing, we can address the challenges facing geothermal development by improving with trustworthy legislation and raising public awareness through basic education to build a brighter future for our communities.

II. GEOTHERMAL FACTS

Geothermal energy development for Net-zero policy: Located in the pacific rim of fire and collision zone of the Eurasia and Philippine Sea plates, Taiwan possesses abundant geothermal resources. Based on island-wide exploration data, Taiwan's shallow and deep geothermal potential is estimated at about 1 GW and 33.6 GW, respectively. The figure 1 and 2 display the estimated geothermal potential distribution and the current status of geothermal power plant development around the different counties, respectively.

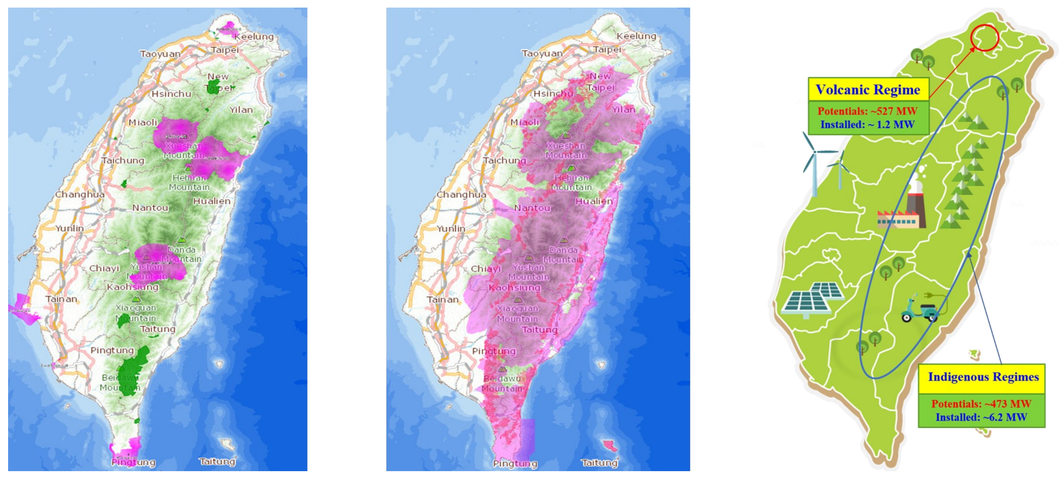
To reduce the emissions of green-house gas (GHG) and to achieve the goal of net-zero carbon emissions in 2050, Taiwan sets up a new energy portfolio to be as (1) 60-70% renewable and 9-12% hydrogen energy, (2) 20-27% thermal power generation with carbon capture, utility and storage (CCUS), and (3) 1% hydropower. Among the renewable energy, the geothermal will play the third significant role after solar and wind powers, especially the enhanced geothermal system.



Figures 1/2: from left to right, 1. Geothermal potential distribution map of Taiwan; 2. Progress of the power plant development with its geothermal potential in each of the five regions of Taiwan.

Geothermal for sustainable development: UN's SDGs are the most comprehensive framework for sustainable human development, balancing environmental health with global prosperity and equality. These goals advocate for substituting fossil fuels to improve air quality, thus providing crucial public health benefits and protecting the planet for a better humanity.

From the maps below, (1) much of the high potential geothermal resource, ex. the Tatun Volcanic Group site in the northern tip of Taiwan with approximately half of Taiwan's total geothermal capacity, overlaps with Yangmingshan National Park; (2) The indigenous traditional lands cover approximately 80% of high-potential geothermal zones.



Figures 3/4/5: from left to right, 3. The national parks (pink) and natural reserves (green); 4. The indigenous territories (pink); 5. The distribution of two main geothermal types, the Volcanic Area overlaps with a National Park, and the quick-uplift Mountain Area overlaps with the indigenous traditional lands.

IV. CONCLUSIONS & FUTURE APPROACH

Geothermal energy is critical for Taiwan's sustainable development because it provides reliable and stable baseload power, leads to reduce carbon emissions (for the net-zero goal), optimizes land use (small footprint), and stimulates economic growth (industrial transformation).

The two principal hurdles hindering geothermal development have to be removed,

1. **Regulatory restrictions on national park lands**: create designated "renewable energy zones" in certain buffer area to allow related activities with feedback terms in less restricted zones with legal reform; adopt technological approach such as deep or directional drilling.
2. **Conflicts over land rights with indigenous communities**: Build mutual trust between the local community and the government body, provide useful data and meaningful consultation with dignity, and joint partnership in education/development/benefits to reduce resistance for cooperation.

Acknowledgements

I would like to express my appreciation to my co-authors for their constant input and discussion. This study was kindly funded and made possible by the National Science and Technology Council, the Republic of China under the project grants of NSTC 113-2811-M-002-104 and 114-2811-M-002-069.

Also, credited to the AI tool of Gemini Nano Banana for producing certain figures by providing related key words.

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