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EVALUATING GEOTHERMAL ENERGY DEVELOPMENT IN TAIWAN USING MULTI-CRITERIA DECISION-MAKING (MCDM): CHALLENGES AND STRATEGIC PRIORITIES

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Abstract

Taiwan's geothermal energy sector presents a promising yet underdeveloped opportunity for sustainable energy transition. Despite its moderate geothermal potential, development has been slow due to regulatory challenges, financial constraints, and technological limitations. This research applies a Multi-Criteria Decision-Making (MCDM) method to systematically asses key factors influencing geothermal energy development in Taiwan. The analysis considers criteria such as resource availability, government policies, economic feasibility, environmental impact, and technological advancements. According to the findings, the main priorities for geothermal development are energy-related factors, including supply security and energy generation reliability. The results indicate that while Taiwan's policy framework has improved with recent incentives under the Renewable Energy Development Act, financial risks and technological constraints remain critical barriers. By prioritizing these factors, the study provides strategic insights for policymakers and investors to enhance decision-making, streamline regulatory processes, and accelerate geothermal energy adoption in Taiwan.

Keywords: Geothermal Energy, Multi-Criteria Decision-Making Method, Analytic Hierarchy Process, Energy Policy, Taiwan

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INTRODUCTION

Climate change, energy insecurity, and the depletion of fossil fuel resources have made the switch to renewable energy sources a global need. Particularly in geologically active areas like Taiwan, geothermal energy offers a significant chance to promote sustainable energy transitions as a clean, dependable, and base-load renewable resource. Due to a number of obstacles, such as financial, technological, and regulatory ones, Taiwan's geothermal resource development is still comparatively underdeveloped despite its moderate potential (Chen et al., 2007; Huang & Yang, 2000).

Since more than 97% of Taiwan's energy supply comes from imports, the country's energy security is a critical concern (Bureau of Energy, 2009a). Due to its significant reliance on imported fossil fuels, the nation is extremely susceptible to supply shortages, market instability, and geopolitical unrest. Accordingly, increasing domestic energy output using geothermal and other renewable energy sources has become a top national priority (International Energy Agency, 2004;

Asif & Muneer, 2007). The "Three E" goals—energy security, environmental preservation, and economic growth—have been incorporated into the Ministry of Economic Affairs' Sustainable Energy Policy Principles since 2008 in recognition of this.

These objectives are supported by the clear benefits that geothermal energy provides. In comparison to fossil fuel-based energy systems, it can drastically cut greenhouse gas emissions and offer a steady and uninterrupted supply of electricity, enhancing energy reliability (Hirsch, 2002; Sørensen, 2007) (Komor & Bazilian, 2005; Wang & Feng, 2002). Additionally, if properly supported, geothermal development can promote local development and open up economic prospects (Lior, 2010; Chatzimouratidis & Pilavachi, 2008).

Implementing policies, however, necessitates carefully balancing conflicting goals and standards. In this regard, the Analytic Hierarchy Process (AHP) and other multi-criteria decision-making (MCDM) techniques are very useful for organizing and evaluating intricate policy trade-offs (Saaty, 1980; Erkut & Tarimcilar, 1991). Strategic priorities in energy planning can be identified thanks to AHP's ability to quantitatively evaluate policy options based on expert assessment.

The AHP approach is used in this study to assess the key variables affecting Taiwan's development of geothermal energy. The study intends to offer strategic recommendations for investors, legislators, and other stakeholders engaged in Taiwan's transition to renewable energy by evaluating the relative significance of energy security, environmental, and economic factors.

LITERATURE REVIEW

The conventional understanding of governmental renewable energy policy posits its primary objective as the increased deployment of renewable energy sources. However, a comprehensive analysis reveals a multifaceted policy landscape encompassing several interconnected goals. For instance, Komor and Bazilian (2005) contend that the various motivations underpinning Ireland's renewable energy policy can be categorized into energy, environmental, and economic/industrial objectives. Similarly, the International Energy Agency (IEA) highlights that policymakers in its member countries frequently perceive renewable energy as instrumental in enhancing energy security, fostering environmental protection, and stimulating economic development, collectively referred to as the "three Es".

As an island nation, Taiwan is largely dependent on energy imports, with over 97% of its supply originating from external sources. Consequently, Taiwan endeavors to leverage renewable energy to address the dual challenges of substantial carbon emissions and the depletion of fossil fuels. The Sustainable Energy Policy Principles, promulgated in 2008 by the Ministry of Economic Affairs, explicitly mandate that renewable energy policy should concurrently achieve these three aforementioned "E" goals.

The energy security goal encompasses objectives such as maintaining low and stable energy prices, ensuring a secure energy supply, and providing stable energy generation for domestic, industrial, and national requirements. The environmental protection goal is directed towards the reduction of carbon and other emissions, the promotion of environmental sustainability. The economic development goal anticipates that geothermal development policy will stimulate economic growth and increase employment within Taiwan.

Geothermal Energy

Geothermal power has been used since ancient times. It was not appreciated until the first usage of geothermal power for electricity generation was demonstrated in 1904. Since 2000, the global usage of geothermal has accelerated just as rapidly both because of the push for energy alternatives and recent technological advances.

Taiwan is an island extruded by the Eurasian Plate and the Philippine Sea Plate; consequently, the nation has abundant geothermal resources. The potential is around 1,000 MW generation capacity, according to the investigation of over 26 major geothermal sites in Taiwan (Huang & Yang, 2000). The economically and technically feasible exploitation is only about 150 MW (Chen et al., 2007). In Taiwan, the main application of geothermal energy is electricity generation. The most promising site is the Chin-Suei geothermal energy project located at Yi-Lan County, which is developed by the local government using a build, operate, and transfer method (BOT) for multiple uses of geothermal resources.

Energy Goal

Taiwan's pursuit of geothermal technology is primarily aimed at achieving the energy objectives of stable and affordable energy prices, a secure energy supply, and consistent energy generation to meet household, industrial, and national demands. To realize these objectives, the evaluation of geothermal technology must consider its capacity to mitigate energy price volatility, enhance energy supply security, maintain low energy costs, and ensure supply stability.

Energy Price Stability

Fossil fuel prices are subject to increasing volatility, influenced by factors such as escalating demand from rapidly developing economies, geopolitical instability, and natural disasters (Komor & Bazilian, 2005; Bureau of Energy of Ministry of Economic Affairs, 2007). Given that Taiwan's electricity generation relies significantly on coal (38.5%), natural gas (28.6%), and oil (9.8%) (Bureau of Energy of Ministry of Economic Affairs, 2009a), the electricity sector is particularly susceptible to these price fluctuations. Proposed adjustments to electricity prices have consequently elicited considerable discontent from both industrial and household consumers. The advancement of geothermal source can, therefore, serve to buffer Taiwan from fluctuations in international energy markets.

Security for Energy Supply

Energy security is defined as the consistent availability of a sufficient and dependable energy supply (Asif & Muneer, 2007). The IEA recommends that the development of renewable energy should explicitly incorporate energy security considerations (International Energy Agency, 2004). The majority of Taiwan's electricity is generated from imported fuels, including coal, natural gas, and oil. This high reliance on imported resources renders Taiwan significantly exposed to international economic and political shifts, which can manifest as price fluctuations. Furthermore, these risks could potentially lead to energy supply shortages (Komor & Bazilian, 2005). Among Taiwan's imported fuels, the supply of natural gas and crude oil is particularly susceptible to international market dynamics. Consequently, the exploitation of geothermal technology enhances the security of the national energy supply.

Low Energy Prices

Energy serves as a fundamental economic input across various sectors, including transportation, industry, agriculture, residential, and services. Low energy prices contribute to reduced production costs, thereby facilitating economic growth. Moreover, energy is a fundamental necessity for heating, cooking, and transportation (Komor & Bazilian, 2005). Sustaining low energy prices is therefore crucial for maintaining the living standards of residents29. However, due to the technical difficulties, geothermal energy prices are typically higher than those of fossil fuels. To preserve residents' fundamental living standards and national competitiveness, the economic implications of geothermal energy utilization, specifically concerning energy prices, must be meticulously considered.

Stability for Energy Generation

A notable limitation in several renewable energy technologies, particularly wind and solar energy, is their unpredictable and intermittent electrical power output, which currently precludes their sole reliance for all-renewable electricity production (Hirsch, 2002). To enable a future characterized by entirely renewable electricity generation, extensive research in geothermal technology is focused on mitigating this drawback (Chen et al., 2007; Sørensen, 2007; Moriaty & Honnery, 2007). Accordingly, this study posits that the stability of energy generation is an essential criterion for consideration in the assessment of geothermal technology.

Environmental Goal

Environmental concerns have garnered increasing attention in recent years, largely attributed to climatic issues stemming from elevated levels of carbon emissions and pollution. Geothermal energy is also anticipated to contribute significantly to the Taiwanese government's attainment of its environmental objectives. The evaluation of geothermal technology, in relation to the environmental goal, should encompass considerations of carbon and other emissions reductions, environmental sustainability, and minimal land requirements.

Carbon Emissions Reduction

According to investigations by the International Energy Agency, Taiwan ranked 17th globally in CO_2 emissions per capita and 20th in total CO_2 emissions. Substantial action within the energy sector will be imperative for the Taiwanese government to ameliorate its environmental standing. Consequently, the capacity of geothermal energy to reduce carbon emissions should be a primary consideration in its assessment (Wang & Feng, 2002; Komor & Bazilian, 2005; Lee et al., 2007).

Other Emissions Reductions

Beyond carbon dioxide, the combustion of fossil fuels releases various compounds that contribute to air pollution. A key expectation for the utilization of geothermal energy is its potential to mitigate air pollutants, which are detrimental to human health (Beccali et al., 2003; Komor & Bazilian, 2005; Mohamadabadi et al., 2009).

Environmental Sustainability

Sustainability is commonly defined as development that fulfills the needs of the present generation without compromising the capacity of future generations to meet their own needs (World Commission of Environment and Development, 1987). While geothermal energy is widely regarded as a substitute for fossil fuels in the pursuit of environmental sustainability, the environmental impacts associated with its exploitation warrant careful evaluation. These impacts may include landscape alteration, earthquake, unpleasant odors, and microclimatic changes (Beccali et al., 2003).

Low Land Requirement

It is important to acknowledge that due to the unique location requirement of geothermal energy, the amount of energy generated per unit of land area is comparatively small (Hirsch, 2002). To achieve energy capacities comparable to those of fossil fuels, geothermal energy installations often necessitate extensive land areas for energy conversion. Furthermore, human activities are recognized as significant contributors to environmental pressure. A substantial demand for land can also result in economic losses, proportional to the specific value of the site and potential alternative land uses (Beccali et al., 2003).

Economic Goal

The Taiwanese government anticipates that renewable energy policy will also achieve economic objectives, particularly stimulating national economic growth and increasing employment (National Science Council, 2009).

Local Economic Development

Historically, Taiwan's economic development has been significantly driven by its technology industry. Currently, the Taiwanese government aims to restructure the industrial landscape to foster economic growth through the development of renewable energy especially the geothermal technology. Consequently, the economic benefits derived from geothermal energy development should be rigorously evaluated.

Increasing Employment

Taiwan's unemployment rate has emerged as a significant national concern in recent years. The creation of employment opportunities is a crucial consideration in geothermal energy policy, and sustainable energy development should actively promote innovation, increased employment, and enhanced job satisfaction (Lior, 2010). Therefore, the potential for employment generation is a vital criterion in the assessment of geothermal technology for achieving economic goals (Komor & Bazilian, 2005; Erdoğmuş et al., 2006; Chatzimouratidis & Pilavachi, 2008).

Technical Maturity

The technical maturity of an applied technology is an essential evaluative factor (Beccali et al., 2003). A higher degree of maturity in an emerging technology correlates with greater prospects for successful implementation (Huang et al., 2008). Consequently, it is imperative to assess the technical maturity of geothermal energy technologies to ensure their alignment with Taiwan's renewable energy policy's economic objectives.

Potential for Commercialization

While geothermal remain technically immature and are currently confined to pilot plant operations, thus precluding large-scale utilization. Various nations have implemented policy measures to facilitate the commercialization of geothermal energy technologies, aiming to secure a competitive position for their domestic geothermal energy industries in the global market (Hakkila, 2006; Zegers, 2006). These studies collectively suggest that superior commercialization potential for a technology is crucial for achieving economic objectives. Therefore, evaluating the potential and feasibility of successful commercialization for geothermal energy utilization is paramount to attaining this goal.

Market Size

To achieve the economic objective of stimulating economic growth and increasing employment, a thorough evaluation of the potential market size for geothermal energy and its associated technologies is necessary, encompassing both domestic and international markets (Lee et al., 2007). As an emerging industry, the prospective market size of geothermal energy technologies plays a significant role in establishing industrial competitiveness (Lee et al., 2007; Lewis & Wiser, 2007). A larger market size tends to attract increased corporate investment in this technology, which in turn facilitates the development of related industries.

Reasonableness for Investment Cost

Currently, the investment costs and associated risks of geothermal energy projects remain substantial, often rendering them economically unviable from a purely financial perspective (Powell & Hill, 2010). However, at the national level, the environmental and energy objectives must be weighed against investment costs to ascertain the overall efficiency of geothermal sources (Lee et al., 2007; Chatzimouratidis & Pilavachi, 2009). Numerous studies advocate for the inclusion of investment costs in the assessment of renewable energy utilization (Mamlook et al., 2001; Afgan & Carvalho, 2002; Liposcak et al., 2006; Jovanović et al., 2009).

RESEARCH METHODS

3.1 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a widely utilized multi-criteria decision-making (MCDM) method, introduced by Saaty (1980). It is particularly effective for complex decisions involving multiple interacting factors, such as those encountered in the development of renewable energy technologies. AHP facilitates the assessment of various alternatives against a defined set of criteria.

AHP functions as a multi-objective decision-making and planning tool based on an additive weighting process, where relevant attributes are represented according to their relative importance. Its application spans numerous studies in energy research. Specifically, in energy policy analysis, AHP enables the hierarchization of policy goals and their associated criteria, allowing for a quantitative estimation of the relative importance of each criterion and alternative. The AHP method is a popular multi-objective decision-making and planning tool that is analysis based on an additive weighting process, in which several relevant attributes are represented according to their relative importance (Erkut & Tarimcilar, 1991). In the specific case of renewable energy policy analysis, the AHP allows the “hierarchization” of different policy goals and their affiliated criteria, making possible a quantitative treatment that leads to a numerical estimate of the relative importance of each criterion and alternative.

Literature review and brainstorming can be used to search for criteria when establishing a hierarchical structure. After that, the criteria are mutually compared for $n \times (n-1)/2$ times if there are n criteria. A nine-point scale recommended by Saaty (1980) is adopted to obtain experts' opinions, with preferences between options given as equally, moderately, strongly, very strongly, or extremely preferred (with pairwise weight of 1, 3, 5, 7, and 9, respectively), and values of 2, 4, 6, and 8 as the intermediate values for the preference scale. Matrix ***A*** can be formed to represent the pairwise comparisons as Equation 9:

$$\boldsymbol{A} = \left[a_{ij}\right] = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ a_{21} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{n1} & a_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \tag{9}$$

where a_{ij} represents the geometric mean that the expert panel compares the criterion *i* with criterion *j*.

To estimate the relative weights of the criteria in this matrix, the priority of the criteria is compared by computing the eigenvalues and eigenvectors with Equation 10:

$$\boldsymbol{A} \cdot w = \lambda_{\max} \cdot w \tag{10}$$

where *w* is the eigenvector of the matrix *A*, and $\lambda_{\max}$ is the largest eigenvalue of the matrix A. The eigenvector w can be obtained by Equation 11:

$$\boldsymbol{w} = \left(\prod_{j=1}^{n} a_{ij}\right)^{1/n} \Bigg/ \sum_{i=1}^{n}\left(\prod_{j=1}^{n} a_{ij}\right)^{1/n} \tag{11}$$

where *n* is the number of criteria being compared in this matrix. The largest eigenvalue $\lambda_{\max}$ of ***A*** can be estimated by using Equation 4:

$$\lambda_{\max} = \frac{1}{n}\sum_{i=1}^{n}\frac{(\boldsymbol{Aw})_i}{w_i} \tag{12}$$

The consistency of the matrix is done by examining the reliability of judgments in the pairwise comparison. The consistency index (CI) and the consistency ratio (CR) are defined as Equations 5 and 6:

$$CI = \frac{\lambda_{\max} - n}{n-1} \tag{13}$$

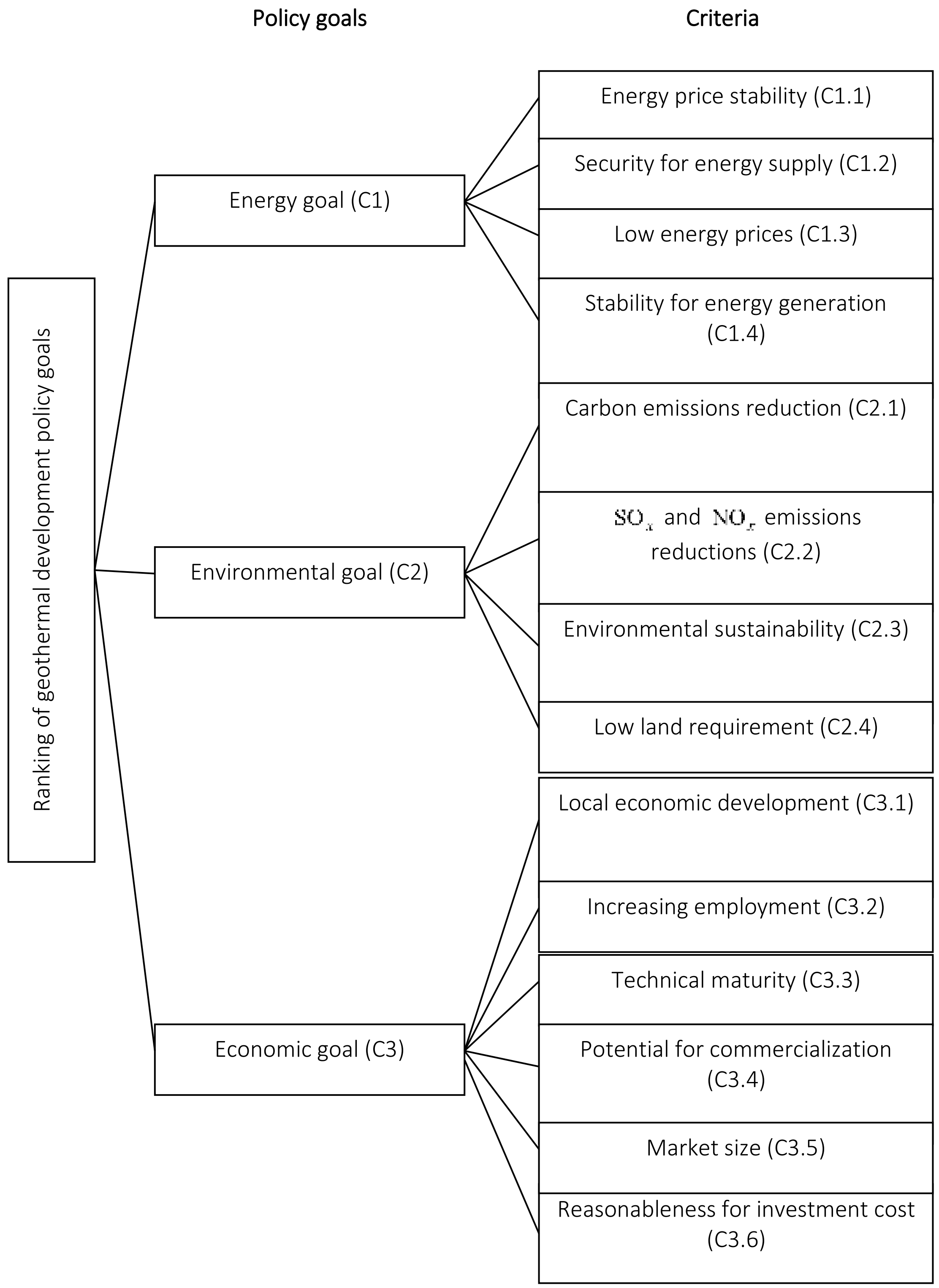
$$CR = \frac{CI}{RI} \tag{14}$$

where *n* is the number of criteria being compared in this matrix, and RI is the random index. The average consistency index of a randomly generated pairwise comparison matrix of similar size is shown in Table 3.

Table 3. Random index (RI)

N	1	2	3	4	5	6	7	8
R.I.	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41
N	9	10	11	12	13	14	15	
R.I.	1.45	1.49	1.51	1.48	1.56	1.57	1.59	

3.2 AHP Framework


Policy goals
Criteria
Ranking of geothermal development policy goals
Energy goal (C1)
Environmental goal (C2)
Economic goal (C3)
Energy price stability (C1.1)
Security for energy supply (C1.2)
Low energy prices (C1.3)
Stability for energy generation (C1.4)
Carbon emissions reduction (C2.1)
SO_x and NO_x emissions reductions (C2.2)
Environmental sustainability (C2.3)
Low land requirement (C2.4)
Local economic development (C3.1)
Increasing employment (C3.2)
Technical maturity (C3.3)
Potential for commercialization (C3.4)
Market size (C3.5)
Reasonableness for investment cost (C3.6)

RESULTS AND DISCUSSION

4.1. Result of Geothermal AHP

rank	Criterion name	Criterion weight
1	C1	0.387
2	C2	0.33
3	C3	0.282

As shown in the table above, According to the Ranking of Policy Goals, C1 is the first priority. Next priorities are assigned to C2 and C3 according to the obtained weights. The highest priority is Energy Goal, meaning stakeholders believe geothermal energy's value in stabilizing energy supply and prices is most critical. Environmental and economic goals, though important, are secondary.

rank	Criterion name	Criterion weight
3	C 1.1	0.2
2	C1.2	0.3
4	C1.3	0.196
1	C1.4	0.304

As shown in the table above, According to the C1, C1.4 is the first priority. Next priorities are assigned to C1.2, C 1.1 and C1.3 according to the obtained weights. The most important factor under the energy goal is stability in energy generation (C1.4), highlighting geothermal's advantage as a reliable, base-load renewable energy source compared to intermittent sources like solar and wind. Energy security (C1.2) is also crucial, likely due to Taiwan's high dependence on imported fuels.

Rank	Criterion name	Criterion weight
1	C2.1	0.32
3	C2.2	0.253
2	C2.3	0.294
4	C2.4	0.133

As shown in the table above, According to the C2, C2.1 is the first priority. Next priorities are assigned to C2.3, C2.2 and C2.4 according to the obtained weights. Carbon emission reduction is viewed as the most urgent environmental benefit of geothermal energy. While land use concerns are acknowledged, they are seen as less pressing compared to emissions.

Rank	Criterion name	Criterion weight
3	C3.1	0.171
5	C3.2	0.156
2	C3.3	0.176
4	C3.4	0.166
6	C3.5	0.15
1	C3.6	0.181

As shown in the table above, According to the C3, C3.6 is the first priority. Next priorities are assigned to C3.3, C3.1, C3.4, C3.2 and C3.5 according to the obtained weights. The cost of investment and technical maturity are seen as the biggest economic hurdles for geothermal development. Interestingly, job creation and market size rank lower, suggesting that financial viability is a bigger concern than labor or market growth.

Rank	Criterion name	Criterion weight
6	C 1.1	0.0774
2	C1.2	0.1161
7	C1.3	0.075852
1	C1.4	0.117648
3	C2.1	0.1056
5	C2.2	0.08349
4	C2.3	0.09702
13	C2.4	0.04389
10	C3.1	0.048222
12	C3.2	0.043992
9	C3.3	0.049632
11	C3.4	0.046812
14	C3.5	0.0423
8	C3.6	0.051042

As shown in the table above, According to the Ranking of Policy Goals, C1.4 is the first priority. Next priorities are assigned to C1.2, C2.1, C2.3, C2.2, C 1.1, C1.3, C3.6, C3.3, C3.1, C3.4, C3.2, C2.4 and C3.5 according to the obtained weights. This final ranking highlights that technical reliability (C1.4 and C1.2) and emissions reduction (C2.1) dominate decision-making. Meanwhile, market size, employment, and land use are considered less critical.

4.2. Discussion

The Analytic Hierarchy Process (AHP) was used in this study to methodically rank important policy objectives and standards affecting Taiwan's geothermal energy development. The findings offer insightful information about stakeholder preferences and the relative significance of different elements in the development of geothermal energy policy.

According to the research, energy security (C1) was the most important of the three primary policy goals (weight = 0.387), followed by environmental sustainability (C2) at 0.330 and economic development (C3) at 0.282. This suggests that, given Taiwan's heavy reliance on imported fossil fuels, stakeholders and experts see geothermal energy primarily as a tool to improve the country's energy resilience and reliability. Prioritizing energy goals is in line with Taiwan's national strategy to guarantee a steady supply of electricity and lessen reliance on outside energy sources.

The most important criterion within the energy aim was stability of energy generation (C1.4) (0.304), closely followed by security of energy supply (C1.2) at 0.300. In contrast to intermittent sources like wind and solar, geothermal energy has the distinct advantage of being a base-load renewable source that can run continuously. These results support the strategic importance of geothermal energy in preserving a stable electrical grid and reducing the likelihood of an interruption in the energy supply.

Reducing carbon emissions (C2.1) was given priority under the environmental goal (0.320), while environmental sustainability (C2.3) came in second at 0.294. These findings demonstrate how urgent it is for Taiwan to cut its greenhouse gas emissions and how concerned people are becoming about climate change. Geothermal energy is a great option for bolstering national and international climate pledges because of its comparatively low carbon impact.

Concerns regarding the financial viability of geothermal projects have persisted, as evidenced by the highest priority (0.181) given to investment cost reasonableness (C3.6) in the economic component. The requirement for cutting-edge, tested technologies that can generate economic value and promote regional growth is demonstrated by the close relationship between technical maturity (C3.3) and local economic development (C3.1). Curiously, the AHP model's lowest weights went to market size (C3.5) and employment generation (C3.2), indicating that although economic benefits are desirable, they are not currently the most important factors in geothermal decision-making.

This tendency is supported by the total rating of all 14 sub-criteria. The reduction of carbon emissions (C2.1), energy supply security (C1.2), and energy generation stability (C1.4) are the key priorities. Sustainability in the environment and other emission reductions come next. On the other hand, elements such as market size (C3.5), employment impact (C3.2), and land usage (C2.4) rank far lower, indicating that stakeholders prioritize environmental performance and technical dependability over more general socioeconomic results.

These results give investors and politicians strong strategic guidance. Enhancing the technical dependability and economic viability of geothermal technology should be the focus of short- to medium-term efforts. Concerns about investment and technical maturity may be addressed with the use of policy tools including feed-in tariffs, public R&D assistance, and risk-sharing arrangements. Furthermore, highlighting geothermal's contribution to emission reduction could improve its standing in Taiwan's larger renewable energy mix.

CONCLUSIONS AND SUGGESTIONS

5.1. Research Conclusions

The Analytic Hierarchy Process (AHP) was used in this study to assess Taiwan's strategic priorities for the development of geothermal energy. This research offers a comprehensive knowledge of the elements that most impact geothermal policy decisions by methodically evaluating the three main policy goals—economic development, environmental sustainability, and energy security—as well as their corresponding sub-criteria.

The findings show that the energy aim is the most important priority, with a special emphasis on energy supply security and generation stability. These results demonstrate Taiwan's pressing need to guarantee consistent, dependable energy supply and lessen reliance on imported fossil fuels. The potential importance of geothermal energy in Taiwan's climate change mitigation plans was further supported by the high ranking of environmental factors, particularly the reduction of carbon emissions.

Despite their acknowledged importance, economic criteria including technical maturity and investment cost are seen as secondary to environmental performance and energy reliability. This implies that solving strategic energy and environmental issues is the key driving force for geothermal development, even while economic viability is still an issue.

As long as technical, financial, and regulatory obstacles are removed by focused policy changes and calculated investment, geothermal energy is seen as a viable option for Taiwan's energy transition, according to the AHP report.

5.2. Research Suggestions

Future research in a number of areas is advised in order to build on the results of this study:

Including Fuzzy AHP or ANP (Analytic Network Process): To better manage uncertainty and interdependence among criteria, future research may use fuzzy logic or network-based extensions of AHP.

Comparative Cross-Country Analysis: A research that compares Taiwan to other island states or nations with comparable geothermal potential (such as Indonesia, Japan, or Iceland) may highlight contextual variations and best practices.

Stakeholder-Specific Prioritization: Dividing the analysis into groups of stakeholders, including representatives from the public, commercial, and community sectors, may reveal varying viewpoints and points of agreement about geothermal energy policy.

Policy Impact Simulation: Using scenario analysis or dynamic modeling, it may be possible to evaluate how shifting market conditions, technological costs, or policy changes may affect the order of importance of geothermal development criteria over time.

Future research might also look at how geothermal energy fits into Taiwan's overall energy balance and how it works in tandem with other renewable energy sources like hydroelectricity, wind, and solar.

Future studies can offer more complex and useful insights for stakeholders looking to hasten Taiwan's transition to renewable energy by broadening and deepening geothermal research in these areas.

BIBLIOGRAPHY

Afgan, N. H. & Carvalho, M. G. (2002). Multi-criteria assessment of new and renewable energy power plants. Energy, 27(8), 739-755.

Asif, M. & Muneer, T. (2007). Energy supply, its demand and security issues for developed and emerging economies. Renewable and Sustainable Energy Reviews, 11(7), 1388-1413.

Beccali, M., Cellura, M. & Mistretta, M. (2003). Decision-making in energy planning: Application of the Electre method at regional level for the diffusion of renewable energy technology. Renewable Energy, 28(13), 2063-2087.

Bureau of Energy of Ministry of Economic Affairs. (2007). 2007 Energy Technology Research and Development White Book. Taipei: Bureau of Energy of Ministry of Economic Affairs.

Bureau of Energy of Ministry of Economic Affairs. (2009a). Energy Statistics Handbook 2008. Taipei: Bureau of Energy of Ministry of Economic Affairs.

Bureau of Energy of Ministry of Economic Affairs. (2009b). Annual Report 2008. Taipei: Bureau of Energy of Ministry of Economic Affairs.

Chatzimouratidis, A. I., & Pilavachi, P. A. (2008). Sensitivity analysis of the evaluation of power plants impact on the living standard using the analytic hierarchy process. Energy Conversion and Management, 49(12), 3599-3611.

Chen, F., Lu, S. M. & Chang, Y. L. (2007). Renewable energy in Taiwan: Its developing status and strategy. Energy, 32(9), 1634-1646.

Erdoğmuş, Ş., Aras, H. & Koç, E. (2006). Evaluation of alternative fuels for residential heating in Turkey using analytic network process (ANP) with group decision-making. Renewable and Sustainable Energy Review, 10(3), 269-279.

Erkut, E. & Tarimcilar, M. (1991). On sensitivity analysis in the analytic hierarchy process. IMA Journal of Mathematics Applied in Business & Industry, 3(1), 61-83.

Hakkila, P. (2006). Factors driving the development of forest energy in Finland. Biomass and Bioenergy, 30(4), 281-288.

Hirsch, R. L. (2002). Electric power from renewable energy: Realities for policy-makers. Journal of Fusion Energy, 21(3-4), 173-180.

Huang, B. J. & Yang, C. Y. (2000). Renewable energy in the 21st century for Taiwan. In: World Renewable Energy Congress VI, 1739-1743.

Huang, C. C., Chu, P. Y. & Chiang, Y. H. (2008). A fuzzy AHP application in government-sponsored R&D project selection. Omega, 36(6), 1038-1052.

International Energy Agency. (2004). Renewable Energy: Market & Policy Trends in IEA Countries. Paris: International Energy Agency.

International Energy Agency. (2009). Key World Energy Statistics 2009. Paris: International Energy Agency.

Jovanović, M., Afgan, N., Radovanović, P. & Stevanović, V. (2009). Sustainable development of the Belgrade energy system. Energy, 34(5), 532-59.

Komor, P. & Bazilian, M. (2005). Renewable energy policy goals, programs, and technologies. Energy Policy, 33(14), 1873-1881.

Lee, S. K., Yoon, Y. J., & Kim, J. W. (2007). A study on making a long-term improvement in the national energy efficiency and GHG control plans by the AHP approach. Energy Policy, 35(5), 2862-2868.

Lewis, J. I. & Wiser, R. H. (2007). Fostering a renewable energy technology industry: an international comparison of wind industry policy support mechanisms. Energy Policy, 35(5), 1844-1857.

Liposcak, M., Afgan, N. H., Duic, N. & da Craca Carvalho, M. (2006). Sustainability assessment of cogeneration sector development in Croatia. Energy, 31(13), 2276-2284.

Lior, N. (2010). Sustainable energy development: The present (2009) situation and possible paths to the future. Energy, 35(10), 3976-3994.

Mamlook, R., Akash, B. A. & Mohsen, M. S. (2001). A neuro-fuzzy program approach for evaluating electric power generation systems. Energy, 26(6), 619-632.

Mohamadabadi, H. S., Tichkowsky, G., & Kumar, A. (2009). Development of a multi-criteria assessment model for ranking of renewable and non-renewable transportation fuel vehicles. Energy, 34(1), 112-125.

Moriaty, P. & Honnery, D. (2007). Intermittent renewable energy: the only future source of hydrogen? International Journal of Hydrogen Energy, 32(12), 1616-1624.

National Science Council (2009). The Concluding Report for the Core Issue of Energy Technology and Industry Development. Taipei: National Science Council.

Powell, E. E., & Hill, G. A. (2010). Carbon dioxide neutral, integrated biofuel facility. Energy, 35(12), 4582-4586.

Saaty, T. L. (1980). The analytic hierarchy process. New York: McGraw-Hill.

Sørensen, B. (2007). A renewable energy and hydrogen scenario for northern Europe. International Journal of Energy Research, 32(5), 471-500.

Wang, X. & Feng, Z. (2002). Sustainable development of rural energy and its appraising system in China. Renewable and Sustainable Energy Reviews, 6(4), 395-404.

World Commission of Environment and Development. (1987). Our Common Future. Oxford: Oxford University Press.

Zegers, P. (2006). Fuel cell commercialization: the key to a hydrogen economy. Journal of Power Sources, 154(2), 497-502.