



Attracting Students to Renewable Energy: Direct-Use Geothermal Potential in Garut Regency as a Contextual Resource for Science Education

Aria Amanda^{1*}, Farhatul Zanah¹, Amar Amrullah², Asep Irvan Irvani²

¹ Department of Science Education, Universitas Garut, Garut, Indonesia.

² Department of Physics Education, Universitas Garut, Garut, Indonesia.

Received: 09-09-2025

Revised: 16-09-2025

Accepted: 20-09-2025

Published: 30-09-2025

Corresponding Author:

Author Name*: Aria Amanda

Email*: ariaamanda413@gmail.com

© 2025 The Authors. This open access article is distributed under a (CC-BY License)



Abstract: The direct use of geothermal energy in Garut Regency remains underutilized, despite the area's considerable potential based on surface manifestations such as hot springs, fumaroles, and warm ground across several locations. This study aims to examine the potential and development direction of direct-use geothermal energy in Garut through a descriptive qualitative approach. Data were collected through in-depth interviews with the Garut Regency Office of Industry and Trade (Disperindag) and literature studies from various scientific and technical sources. The findings show that the geothermal fluid temperature in most locations is around 40°C, which is not suitable for electricity generation but highly potential for direct-use applications such as hot spring tourism and agricultural drying. The main barriers to development include limited technical data, lack of local incentives, and unsynchronized regulations and supporting infrastructure. This study contributes to offering development strategies based on local potential and encourages collaboration among stakeholders. These findings are also relevant as a reference for contextual science education focused on renewable energy and environmental sustainability.

Keywords: renewable energy; geothermal; direct use; local potential; Garut Regency.

Introduction

Indonesia possesses geothermal reserves of approximately 23.7 gigawatts (GW), which accounts for nearly 40% of the world's total potential. With this figure, Indonesia ranks second only to the United States as the country with the largest geothermal potential (Laksono et al., 2023). This potential figure is further supported by official government data (Indonesia., 2022) and other studies highlighting the critical role of geothermal energy for national energy resilience (Sahdarani et al., 2020). Despite this, the utilization of geothermal energy, particularly in its direct use, remains suboptimal in many regions, including Garut Regency. However, the direct utilization of geothermal energy plays a vital role in supporting the clean energy transition and can be leveraged as a source of local-potential-based learning, especially in Science Education in schools.

Garut Regency has numerous geothermal manifestations spread across various areas. Some of these include Cipanas, Darajat, Papandayan, Talaga Bodas, as well as other areas like Pasir Jengkol,

How to Cite:

Amanda, A., Zanah, F., Amrullah, A., & Irvani, A. I. (2025). Attracting students to renewable energy: Direct-use geothermal potential in Garut Regency as a contextual resource for science education. *Journal of Educational Innovation and Technology*, 1(3). <https://journal.sigufi.com/index.php/jeit/index>

Pakenjeng, Cisewu, Bungbulang, and Talegong (Ar-rafi & Wibowo, 2025). Areas such as Cipanas and Darajat have indeed been developed into hot spring tourist areas. Nevertheless, other locations are yet to be optimally utilized. The main obstacles are the limitation of technical data, particularly fluid temperature, and the lack of support in terms of policy and infrastructure.

Interviews with the Department of Industry and Trade (Disperindag) of Garut Regency indicate that the geothermal fluid temperature in most locations is only around. This temperature is not high enough for power generation but has significant potential for direct use, such as for drying agricultural products. Hendrasto et al. (2025) have proven that geothermal-based drying equipment with similar temperatures has been successfully and effectively used in other regions, making its development highly feasible in Garut. Nonetheless, geothermal utilization in West Java tends to be limited to high enthalpy for electricity, even though the potential for low-enthalpy direct use is substantial and requires an integrated empowerment model (Mulyana et al., 2017).

On the other hand, Kalpikajati & Hermawan (2022) highlight that overlapping regulations, lack of regional incentives, and weak planning are obstacles to the development of geothermal energy at the local level. This has led to the slow utilization of geothermal energy potential, both for community needs and as a learning medium.

The majority of previous research has primarily focused on technical aspects or large-scale energy development. Meanwhile, the direct utilization of geothermal energy as a local-potential-based learning resource in Science Education is rarely studied. Yet, such an approach is highly beneficial in fostering students' awareness of renewable energy in their surrounding environment.

Based on this background, this research aims to examine the potential and distribution of geothermal energy in Garut Regency that can be utilized directly, and to explore how this potential can be raised as learning material in Science Education. It is hoped that the results of this research can encourage the wider utilization of local resources and contribute to contextual education and sustainable development.

Method

This study employed a descriptive qualitative approach aimed at examining the potential and formulating the development direction of direct use geothermal energy in Garut Regency. Data were collected from two main sources, namely primary and secondary data. Primary data were obtained through in-depth interviews with the Head of the Geothermal Utilization Section at the Department of Industry and Trade (Disperindag) of Garut Regency. The interviews served as an indirect observation to gather information regarding actual field conditions, such as geothermal fluid temperature at various points, the current level of utilization, as well as the challenges and opportunities in developing direct use geothermal energy.

In addition, secondary data were collected through a literature review of relevant scientific journals and technical documents, such as those written by Ar-rafi & Wibowo (2025), Assegaf et al. (2020), and Kania et al. (2020). Other analyzed documents included geothermal working area (WKP) maps and geological data from official institutions.

All data were analyzed inductively and qualitatively by identifying patterns and relationships among geothermal resource potential, existing utilization forms, and challenges from regulatory and infrastructure perspectives. To ensure data validity, source triangulation was conducted between interview results, official documents, and scientific literature. Through this process, the analysis results are expected to achieve a high level of accuracy and relevance in formulating strategies for the development of direct use geothermal energy that align with the local context of Garut Regency and the principles of sustainability.

Result and Discussion

The distribution of geothermal potential in Garut Regency covers several key locations: Cipanas, Talaga Bodas, Papandayan, Darajat, Pasir Jengkol (Sukawening), Pakenjeng, two points in Cisewu, and the Talegong/Bungbulang area. Most of these locations are situated around active volcanoes, generating natural hot springs that have been utilized by the community for hot spring tourism, such as in Cipanas, Darajat, Papandayan, Talaga Bodas, Pasir Jengkol, and Pakenjeng. Meanwhile, the

locations in Cisewu and Talegong/Bungbulang have not been substantially utilized to date, although the development of tourist facilities in these areas has the potential for further advancement.

These surface manifestations are natural phenomena characterized by the presence of hot springs, warm ground, the emergence of hot gases (fumaroles), hot mud, and similar features. The existence of these geothermal manifestations is closely related to fractures in the rock layers that allow the geothermal fluid to flow to the surface (Ar-rafi & Wibowo, 2025). This is supported by Assegaf et al. (2020), who found that the geothermal potential around Mount Papandayan is influenced by a northeast-southwest geological structure that serves as the pathway for fluid from the underground reservoir. Nugroho & Fadhilah (2021) also showed the presence of a thermal anomaly at Mount Papandayan through remote sensing imagery, indicating a strong correlation between volcanic activity, fracturing, and geothermal manifestations. More detailed geophysical studies in the Karaha-Talaga Bodas area, Garut, using 2D inversion of Magnetotelluric (MT) data successfully modeled the geothermal system, indicating that the Talaga Bodas zone is modeled as a fluid upflow (rising zone), while Karaha is the outflow (exit zone), which technically validates the existence of a large-scale heat source in the region (Arisbaya et al., 2018). These facts demonstrate the great potential for developing direct-use geothermal utilization in various sectors within Garut Regency.

Based on an interview with Mr. Agus Saepudin, S.T., Head of the Geothermal Utilization Section at Garut Disperindag, the direct use of geothermal energy in Garut has so far been focused on the hot spring tourism sector, primarily in Cipanas, Darajat, Papandayan, Talaga Bodas, Pasir Jengkol, and Pakenjeng. Meanwhile, other locations such as Cisewu and Talegong/Bungbulang remain unutilized, despite having hot spring manifestations that can be developed in the future, both for tourism and other sectors.

This constraint aligns with the findings of various previous studies that reveal limitations in investment and technology for low-enthalpy geothermal fields in Indonesia. This finding is supported by Hakim et al. (2022), who noted that geothermal utilization in West Java, including Garut, is still limited to a small scale due to low fluid temperatures and minimal supporting infrastructure. Wisriansyah et al. (2020) added that the development of low-enthalpy geothermal energy, such as in Garut, is hindered by high initial exploration costs. This condition encourages investors to choose simple, low-risk utilization, like hot spring bathing.

In addition to investment challenges, the limitation of fluid temperature also impacts the agricultural and small-industry sectors. Nurrahman et al. (2023) stated that the optimal drying of Cilembu sweet potatoes occurs at temperatures above . (Gunawan et al. (2021) affirmed that West Java's geothermal energy is of the low-to-medium enthalpy type, suitable for bathing but not for industrial processes. Firman & Suyitno (2025) and Wardana et al. (2024) designed solar-based drying equipment and simple ovens with temperatures of , demonstrating the need for temperatures above for optimal drying. Without additional technology, geothermal utilization for these sectors is difficult to optimize. A comparison with the Mount Ciremai Geothermal Working Area (WKP) in Kuningan Regency shows different potential characteristics. In that area, the development of a Geothermal Power Plant (PLTP) with a capacity of 110 MW is directed toward electricity needs because it is supported by high fluid temperatures and adequate supporting infrastructure (Irfan et al., 2025). Meanwhile, the Karaha PLTP project in Garut Regency is still experiencing delays due to technical design constraints and limitations in Human Resources (HR) (Kania et al., 2020). This indicates that the infrastructure readiness in the Garut area is not yet optimal to support large-scale geothermal development.

To understand the distribution of geothermal potential in Garut Regency, an identification was conducted of the geothermal manifestation locations spread across several sub-districts. This data includes information on fluid temperature based on interview results with the Garut Department of Industry and Trade (Disperindag) and previous literature reviews. Furthermore, the current utilization status of each location is also listed, indicating whether it is already utilized for hot spring tourism or remains unutilized optimally. The complete details are presented in Table 1. Distribution of Geothermal Potential in Garut Regency.

Table 1. Distribution of Geothermal Potential in Garut Regency

| No | Location | Fluid Temperature (°C) | Current Utilization |
|----|----------------------------|------------------------|---------------------|
| 1 | Cipanas | < 40 | Hot spring tourism |
| 2 | Darajat | < 40 | Hot spring tourism |
| 3 | Papandayan | < 40 | Hot spring tourism |
| 4 | Talaga Bodas | > 40 | Hot spring tourism |
| 5 | Pasir Jengkol (Sukawening) | < 40 | Hot spring tourism |
| 6 | Pakenjeng | < 40 | Hot spring tourism |
| 7 | Cisewu (two points) | < 40 | Not yet utilized |
| 8 | Talegong/Bungbulang | < 40 | Not yet utilized |

Note: The temperature data is based on interviews with Garut Disperindag and the study by Assegaf et al. (2020). The fluid temperatures for locations other than Cipanas, Darajat, Papandayan, and Talaga Bodas are estimations based on surface manifestation observations, not direct measurement results.

Based on Table 1 (*which is not provided here but referred to*), it can be seen that the locations Cipanas, Darajat, Papandayan, Talaga Bodas, Pasir Jengkol (Sukawening), and Pakenjeng have been utilized as hot spring bathing tourist destinations. Meanwhile, the Cisewu and Talegong/Bungbulang locations have not been substantially utilized to date, despite the existence of geothermal manifestations in those areas.

It must be noted that the fluid temperatures in locations other than Cipanas, Darajat, Papandayan, and Talaga Bodas are still estimates based on observations of surface manifestations, as direct measurement data is not yet available. Therefore, further exploration and study are needed to ascertain the true potential of these locations, especially to encourage the development of direct-use geothermal utilization in the agriculture sector, agricultural product processing, or small-scale industries based on geothermal energy in Garut Regency.

Besides the potential for direct use, Garut Regency also has several Geothermal Working Areas (WKP) that have entered the exploration and development stage for power generation (PLTP). The details of this development status are presented in Table 2, covering the location, development status, and technical description of each WKP.

Table 2. Development Status of Geothermal Working Areas (WKP) in Garut Regency

| No | Location | Status | Description |
|----|------------|---------------------------------|---|
| 1 | Darajat | Active (Geothermal Power Plant) | Capacity of approximately 270 MW - high enthalpy |
| 2 | Karaha | Active (Geothermal Power Plant) | Approximately 30 MW, began COD in 2018 |
| 3 | Papandayan | Potential Only | Numerous surface manifestations, no power plant constructed yet |

Note: The data source is processed from the Garut Regency Department of Industry and Trade (Disperindag) and studies by Kania et al. (2020), and Assegaf et al. (2020).

As shown in Table 2 (*which is not provided here but referred to*), the Darajat and Karaha Geothermal Working Areas (WKP) in Garut Regency have been actively operating as Geothermal Power Plants (PLTP). The Darajat WKP has an installed capacity of approximately 270 MW with high-enthalpy characteristics, while the Karaha WKP began commercial operation in 2018 with a capacity of MW. On the other hand, the Papandayan WKP, to date, only shows potential from surface manifestations such as fumaroles, hot springs, and warm ground, but there has been no significant PLTP development or further exploration activities.

A study by Khasmadin & Udi Harmoko (2021) regarding the Patuha PLTP in Ciwidey indicates that the success of geothermal utilization is heavily influenced by geological characteristics and reservoir structure. With an installed capacity of 55 MW and a steam-dominated system, the Patuha PLTP uses a simple yet effective direct dry steam cycle technology for dry steam sources. Furthermore, long-term project planning and environmental conservation are key to sustainable operation. The study by Ramadhan et al. (2021) in the Baturraden WKP shows that geothermal exploration can trigger significant socio-cultural impacts if not accompanied by an adaptive management strategy.

Decreased community comfort and changes in perception are the most crucial impacts, which can lead to project rejection. Therefore, management strategies based on participatory communication, increased local involvement, and corporate social responsibility are key to the successful implementation of geothermal-based renewable energy.

Zakaria & Susilowati (2020) revealed that there is still a disharmony between geothermal regulations and forest conservation protection, specifically between Law No. 21 of 2014 and Law No. 41 of 1999. This causes confusion in granting permits for geothermal energy utilization in conservation areas, as reflected in the social and ecological conflicts that occurred in the Baturraden PLTP project. They emphasized the need for legal harmonization and community involvement in policy-making to minimize tenure conflicts sustainably.

These findings reinforce the conclusion of this study that geothermal energy development in Garut Regency has so far been predominantly focused on direct use, especially the hot spring tourism sector, while utilization for power generation is only optimal in the Darajat and Karaha areas. This limitation is aggravated by national PLTP technical feasibility standards, which are deemed not fully adaptive for areas like Garut (Heryanto et al., 2023). Additionally, Sekar Arum Kusuma Jati (2024) highlighted the weakness of the new and renewable energy (EBT) legal framework in Indonesia, while ESDM (2025) pointed out the lack of incentives and legal certainty. Subekti & Harmoko (2020) also added that technological constraints and high initial investment limit the development of direct use for non-tourism sectors.

Unlike Japan, which successfully developed extensive geothermal utilization in Beppu and Kusatsu thanks to integrative regulatory support and high-temperature fluid characteristics (Lund & Toth, 2021), geothermal development in Indonesia is still in the early stages, similar to Dieng (Subekti & Harmoko, 2020). West Java Province, including Garut Regency, still faces limitations such as medium-temperature fluids and sub-optimal supporting infrastructure.

The development model for the direct use of geothermal energy in Garut can refer to international practices and local case studies. Based on a study by Endo et al. (2021), geothermal ecotourism development in Japan can serve as a model, with the expansion of geothermal utilization into the agriculture and aquaculture sectors using booster heating technology to overcome non-optimal fluid temperatures. Contextually in West Java, Nadhilah et al. (2025) showed that the Kampung Direct Use (KADIEU) initiative in Patuha successfully utilized geothermal energy directly for greenhouses, drying, and fish cultivation. This model has proven to create sustainable economic, social, and environmental impacts through appropriate technology innovation and community collaboration. Patuha's success indicates that the direct use model is highly suitable for adoption in Garut, which has low-to-medium enthalpy potential. However, this development faces technical and regulatory challenges. Alfianita (2024) noted that fluid mixing at the Wayang Windu Field can reduce system efficiency, thus requiring additional technological innovation to address similar issues in Garut. Furthermore, Dita Aprilia Istiqamah et al. (2023) emphasized that the challenges in geothermal development in Indonesia, besides economic price, are also hampered by complex permitting processes and poor bureaucracy.

Based on the study by Endo et al. (2021), geothermal ecotourism development in Japan can serve as a model for Garut, with the expansion of geothermal utilization into the agriculture and aquaculture sectors using booster heating technology. Alfianita (2024) showed that fluid mixing at the Wayang Windu Field can reduce system efficiency, thus requiring additional technological innovation to address similar issues in Garut. For the optimization of geothermal utilization in Garut, specific research on direct use outside the tourism sector, increased local community education, and pro-geothermal regional policies through fiscal incentives and regulatory simplification are recommended. Synergy among local government, industry players, academia, and the community is expected to drive geothermal utilization in Garut beyond the tourism sector, towards sustainable economic and environmental benefits.

The implication of these findings confirms that the geothermal characteristics in Garut Regency are more suitable for direct use such as hot spring tourism compared to large-scale PLTP (Lukmana et al., 2020). The realistic efforts that can be pursued are the improvement of integrated geothermal

tourism service quality with environmental conservation, supported by close collaboration among the local government, business actors, and the local community.

Conclusion

This research indicates that Garut Regency possesses considerable geothermal potential, distributed across several surface manifestation locations such as Cipanas, Darajat, Papandayan, and Talaga Bodas. The study reveals that the direct use of geothermal energy in this area is still dominated by the hot spring tourism sector. Meanwhile, the potential for utilization in the agriculture sector, small-scale industries, and local-potential-based science learning has not been optimally addressed.

Several identified constraints include the geothermal fluid temperature, which is generally only around, limited technical data in prospective locations, and inadequate regulatory and infrastructure constraints. The main contribution of this research lies in presenting the data on the actual potential distribution and analyzing strategies for developing the direct utilization of low-enthalpy geothermal energy at the local level.

Based on these findings, it is recommended that there be synergy among the local government, industry players, and academics to encourage the diversification of geothermal utilization through the provision of supporting technology, policy incentives, and community education programs. Furthermore, further research is needed to develop appropriate low-enthalpy utilization equipment designs tailored to local conditions, and to comprehensively assess the social and economic impacts of their implementation.

Acknowledgments

The author would like to express gratitude to the Department of Industry and Trade (Disperindag) of Garut Regency, especially to Mr. Agus Saepudin, S.T., as the Head of the Geothermal Utilization Section, for the permission, time, and information provided during the interview and data collection process. Thanks, are also extended to the Science Education Study Program, Universitas Garut, for the academic support provided throughout this research activity. Specifically, the author conveys the highest appreciation to Mr. Amar Amrullah, M.Pd., as the lecturer of the Energy Material course, for the valuable guidance, direction, and motivation in the preparation of this article. Finally, thanks are also addressed to all parties who directly or indirectly assisted and provided support in the completion process of this research.

Author Contributions

Conceptualization, Farhatul Zanah and Aria Amanda; methodology, Farhatul Zanah and Aria Amanda; investigation, Farhatul Zanah and Aria Amanda; data curation, Farhatul Zanah and Aria Amanda; validation and supervision, Amar Amrullah and Asep Irvan Irvani; formal analysis, Farhatul Zanah and Aria Amanda; writing – original draft preparation, Farhatul Zanah and Aria Amanda; writing – review and editing, Amar Amrullah and Asep Irvan Irvani. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Conflicts of Interest

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript; or in the decision to publish the results.

References

- Alfianita, L. (2024). Karakterisasi Manifestasi Permukaan Panas Bumi di Wayang Windu. *Jurnal Teknologi Pertambangan Dan Geosains*, 2(1), 14–25. <https://jurnal.uts.ac.id/index.php/jtpg/article/view/5338>
- Ar-rafi, M. F. S. & Wibowo, N. B. (2025). Analisis Manifestasi Panas Bumi Melalui Fault Fracture Density (FFD). *Journal Technology of Civil, Electrical, Mechanical, Geology, Mining, and Urban Design*, 10(1). <https://doi.org/10.33579/krvtk.v10i1.5571> <https://>
- Arisbaya, L., Aldinofrizal, Sudrajat, Y., Gaffar, E. Z. & Hardja, A. (2018). Model Sistem Panas Bumi Lapangan Karaha - Talaga Bodas Berdasarkan Inversi 2D Data Magnetotellurik. *Riset Geologi Dan*

- Pertambangan*, 28(2). <https://jrisetgeotam.brin.go.id/index.php/jrisgeotam/article/view/989>
- Assegaf, F. T., Hariyanto, A. D., Hutabarat, J. & Gentana, D. (2020). Tipe Dan Estimasi Temperatur Air Bawah Permukaan Daerah Panas Bumi Gunung Papandayan, Garut, Jawa Barat. *Jurnal Geologi Mineral Dan Batubara*, 5(1), 9-20. https://www.researchgate.net/publication/370618692_TIPE_DAN_ESTIMASI_TEMPERATUR_AIR_BAWAH_PERMUKAAN_DAERAH_PANAS BUMI_GUNUNG_PAPANDAYAN_GARUT_JAWA_BARAT
- Dita Aprilia Istiqamah, Sasongko, N. A. & Boedoyo, M. S. (2023). Analisis dampak lingkungan dan life cycle cost pembangkit listrik tenaga panas bumi. *Jurnal Ekonomi Sumberdaya Dan Lingkungan*, 11(1). <https://doi.org/10.22437/jesl.v12i1.26631> <https://online-journal.unja.ac.id/JSEL/article/view/26631>
- Endo, A., Yamada, M., Baba, K., Miyashita, Y., Sugimoto, R., Ishii, A., Nishijima, J., Fujii, M., Kato, T., Hamamoto, H. & Michinori Kimura 11, Terukazu Kumazawa 12, N. M. 13 and H. H. 14. (2021). Methodology for Nexus Approach Toward Sustainable Use of Geothermal Hot Spring Resources. *Frontiers in Water*, 3. <https://doi.org/10.58522/ppsdm22.v5i1.61> https://www.researchgate.net/publication/355200260_Methodology_for_Nexus_Approach_Toward_Sustainable_Use_of_Geothermal_Hot_Spring_Resources
- ESDM, B. (2025). *Pelatihan Teknis Pemanfaatan Langsung Panas Bumi Dorong Pemanfaatan Energi Bersih*. Kementerian Energi Dan Sumber Daya Mineral Republik Indonesia.
- Firman, L. O. M. & Suyitno, B. (2025). Analisis Energi Panas pada Alat Pengering Kacang Mete. *Jurnal Ilmiah Program Studi Magister Teknik Mesin*, 15(1). https://www.researchgate.net/publication/370768008_Analisis_Energi_Panas_pada_Alat_Pengering_Kacang_Mete
- Gunawan, I., Windarta, J. & Harmoko, U. (2021). Overview Potensi Panas Bumi di Provinsi Jawa Barat. *Jurnal Energi Baru & Terbarukan*, 2(2). <https://doi.org/10.14710/jebt.2021.11072>
- Hakim, A. F., Krismadiana, Sholihah, F., Ismawati, R. & Dewantari, N. (2022). Potensi dan Pemanfaatan Energi Panas Bumi di Indonesia. *Indonesian Journal of Conservation*, 11(2). <https://journal.unnes.ac.id/nju/ijc/article/view/40599>
- Hendrasto, F., Sumotarto, U., Meirawaty, M., Guntoro, A. & Fakhmi, N. (2025). Pemanfaatan Energi Panas Bumi Untuk Rancang Bangun Dan Pemasarakatan Alat Pengering Hasil Pertanian Dan Perkebunan. *Jurnal Wahana Abdimas Sejahtera*, 6(1). https://www.researchgate.net/publication/391180084_PEMANFAATAN_ENERGI_PANAS_BUMI_UNTUK_RANCANG_BANGUN_DAN_PEMASYARAKATAN_ALAT_PENGERING_HASIL_PERTANIAN_DAN_PERKEBUNAN
- Heryanto, B., Hamid, H., Novi, K., Setiawan, R. M. & Alisia, D. (2023). Implikasi Pemberlakuan Peraturan Menteri Esdm Nomor 5 Tahun 2021 Tentang Standar Kegiatan Usaha Dan Produk Pada Penyelenggaraan Perizinan Berusaha Berbasis Risiko Sektor Energi Dan Sumber Daya Mineral Terhadap Produktivitas Masyarakat Kabupaten Sukabumi D. *Jurnal Ilmu Pengetahuan Sosial*, 10(12). <https://jurnal.um-tapsel.ac.id/index.php/nusantara/article/view/15386>
- Indonesia., K. E. dan S. D. M. (KESDM) R. (2022). *Handbook Of Energy & Economic Statistics Of Indonesia*. chrome-extension://efaidnbmnnpbcajpcgclefindmkaj/<https://www.esdm.go.id/assets/media/content/content-handbook-of-energy-and-economic-statistics-of-indonesia-2022.pdf>
- Irfan, R., Nasuha, C. N. & Wahyudin, U. (2025). Potensi Dan Pemanfaatan Energi Panas Bumi Gunung Ciremai Sebagai Energi Masa Depan Kuningan Yang Berkelanjutan. *Jurnal ATSAR UNISA*, 4(1). <https://jurnal.unisa.ac.id/index.php/atsar/article/view/761>
- Kalpakajati, S. Y. & Hermawan, S. (2022). Hambatan penerapan kebijakan energi terbarukan di Indonesia. *Batulis Civil Law Review*, 3(2), 187-207. <https://doi.org/10.47268/ballrev.v3i2.1012>
- Kania, B., Kurniawan, A. & Yahya, R. G. (2020). Kajian Keterlambatan Proyek Engineering Procurement Construction Commissioning Jaringan Transmisi 150KV Studi Kasus PLTP Karaha-Gi Garut. *TIARSIE*, 17(1). <https://doi.org/10.32816/tiarsie.v17i1.74>
- Khasmadin, M. F. & Udi Harmoko. (2021). Kajian potensi dan pemanfaatan energi panas bumi di Wilayah Kerja Panas Bumi Patuha Ciwidey. *Jurnal Energi Baru & Terbarukan*, 2(2), 101-113.

- <https://doi.org/10.14710/jebt.2021.11187>
- Laksono, A. D., Habibi, A. A. S., Febiana, D. T., Magfiroh, N. A., Bahri, Nisa, S. & Febriani., S. D. A. (2023). Pemetaan Potensi Energi Panas Bumi Pada Provinsi Sumatera Utara Berbasis Digital Melalui Quantum GIS. *Urnal Engine: Energi, Manufaktur, Dan Material*, 7(1). <https://doi.org/10.30588/jeemm.v7i1.969>
- Lukmana, A. H., Prasetyo, R. M. & Rifani, R. A. (2020). Engineering Design and Feasibility Analysis of Geothermal-heated Swimming Pool in Lembang, West Java. *Journal of Earth Energy Engineering*, 9(2). <https://doi.org/10.25299/jeec.2020.4102>
- Lund, J. W. & Toth, A. N. (2021). Direct utilization of geothermal energy 2020 worldwide review. *Geothermics*, 90. <https://doi.org/10.1016/j.geothermics.2020.101915>
- Mulyana, C., Luthfi, N. & Saad, A. H. (2017). Model Pendayagunaan Energi Goetermal Entalpi Rendah (Direct-Use) di Jawa Barat. *Jurnal Ilmu Dan Inovasi Fisika*, 1(1). <https://doi.org/10.24198/jiif.v1i01.10913>
- Nadhilah, A., Safitri, F. W., Juliana, S. N., Madyani, D., Rahmawati, M. & Yudawinata, G. M. (2025). Kampung direct use: pemberdayaan masyarakat melalui pemanfaatan langsung panas bumi di patuha. *Jurnal Pekerjaan Sosial*, 8(1). <https://jurnal.unpad.ac.id/focus/article/view/65313>
- Nugroho, H. & Fadhilah, M. F. (2021). Identifikasi Daerah Prospek Panas Bumi dengan Menggunakan Teknik Pengindraan Jauh (Studi Kasus: Kecamatan Cisurupan, Kabupaten Garut). *Jurnal Teknik Geodesi Dan Geomatika*, 10(1), 1-8. <https://doi.org/10.26760/jrg.v2018i1.2661>
- Nurrahman, Aziz, R., Ph.D, and iSTP. M. A. L. S., Prof. Ir. Yusuf Hendrawan and STP, M. S. & Dina Wahyu Indriani. (2023). Pengaruh Suhu dan Ketebalan Irisan Terhadap Sifat Fisik Pada Proses Pengeringan Ubi Jalar Cilembu (*Ipomoea batatas* (L.) Lam) Menggunakan Mesin Tray Dryer.
- Ramadhan, M. F., Muslihudin & Effendi, M. (2021). Analisis dampak sosial ekonomi budaya kegiatan eksplorasi panasbumi di WKP Baturraden (Studi kasus di Desa Karangtengah, Kecamatan Cilongok, Kabupaten Banyumas). *Jurnal Ilmu Lingkungan*, 19(1), 117-126. <https://doi.org/10.14710/jil.19.1.117-126>
- Sahdarani, D. N., Ponka, M. A. & Oktaviani, A. D. (2020). Geothermal Energy As An Alternative Source For Indonesia's Energy Security: The Prospect And Challenges Energy Security: The Prospect And Challenges. *Journal of Strategic and Global Studies*, 3(1). <https://doi.org/10.7454/jsgs.v3i1.1024>
- Sekar Arum Kusuma Jati. (2024). Dinamika Hukum Dalam Pengembangan Energi Baru Terbarukan Di Indonesia: Tinjauan Terhadap Aspek Regulasi Dan Implementasinya Dalam Pembangunan Infrastruktur Energi Berkelanjutan. *Jurnal Legal Reasoning*, 6(2). https://www.researchgate.net/publication/396490680_DINAMIKA_HUKUM_DALAM_PENGEMBANGAN_ENERGI_BARU_TERBARUKAN_DI_INDONESIA_TINJAUAN_TERHADAP_ASPEK_REGULASI_DAN_IMPLEMENTASINYA_DALAM_PEMBANGUNAN_INFRASTRUKTUR_ENERGI_BERKELANJUTANDINAMIKA_HUKUM_DALAM_PENG
- Subekti1, R. A. & Harmoko, U. (2020). Overview dan Analisis Potensi Pemanfaatan Langsung (Direct Use) Panas Bumi pada Wilayah Kerja Panas Bumi Dieng Jawa Tengah. *Jurnal Energi Baru & Terbarukan*, 1(3), 133-141. <https://doi.org/10.14710/jebt.2020.10047>
- Wardana, A. R., Mukhtar, A. & Burhanuddin, A. (2024). Analisis Persebaran Panas Pada Mesin Oven Pengerik Kerupuk Dengan Burner Sederhana Berbasis Computational Fluid Dynamics. *Journal of Applied Mechanical Engineering and Renewable Energy*, 4(2), 15-24. <https://doi.org/10.52158/jamere.v4i2.821>
- Wisriansyah, S. Z., Purba, D. & Napitu, A. (2020). Keunggulan, Tantangan, dan Rekomendasi Kebijakan akan Pengembangan Energi Panas Bumi di Indonesia. *Jurnal Nasional Pengelolaan Energ*, 2(2). <https://doi.org/10.37525/mz/2020-2/263>
- Zakaria, A. D. & Susilowati, I. F. (2020). Harmonisasi pengaturan pemanfaatan energi panas bumi pada hutan konservasi. *Novum: Jurnal Hukum*, 7(3), 122-134. <https://ejournal.unesa.ac.id/index.php/novum/article/view/32605>