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Harnessing Residual Geothermal Heat for District Heating in Dieng Plateau: Current Situation and Future Prospects

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ABSTRACT

Geothermal steam and geothermal condensate from the Dieng Geothermal Field contain substantial low enthalpy heat that remains unused in current operations. This study evaluates the feasibility of utilizing this thermal resource for district heating by extracting heat from Condensate Drop Points (CDP) located along the Steam Above Ground System (SAGS). CDP J-03 was selected as the testing location because a combination of pressure drop and elevation driven condensate accumulation creates a stable low temperature heat source. Experimental testing was conducted using a compact shell and tube heat exchanger equipped with helical coils in a counter current configuration. The system produced heated water at 84 to 86°C with a volumetric output of approximately 35.7 liters per minute, indicating strong heat transfer performance. The thermal output exceeds typical domestic gas fired heaters and demonstrates clear potential for direct use geothermal applications. Economic comparison shows that geothermal heating becomes attractive when geothermal pricing is positioned below natural gas and electricity costs. A community-based distribution model with centralized hot water storage offers a practical framework for implementing geothermal district heating in the Dieng region. The results confirm that low enthalpy geothermal heat from CDP can support continuous and scalable hot water production.

1 INTRODUCTION

The Dieng Geothermal Field is located in the volcanic highlands of Central Java, Indonesia, a region commonly known as the Dieng Plateau. The Dieng Geothermal Field represents one of the most significant geothermal resources in Indonesia and is situated at an elevation of approximately 2,000 meters above sea level. The geothermal system lies within an active volcanic complex characterized by fumaroles, hot springs, and additional geothermal surface manifestations. Geothermal exploration in the area began in the 1970s, and commercial operations were initiated in the early 2000s under PT Geo Dipa Energi (Persero). The Dieng Geothermal Field currently operates with an installed capacity of 60 megawatts, consisting of Dieng Unit 1 and the Dieng Geothermal Small Scale Power Plant as complementary of the main unit, which supply electricity to the Java and Bali transmission network (PT Geo Dipa Energi (Persero), 2022).

Steam production in the Dieng Geothermal Field is primarily sourced from the Sileri sector, a deep and high temperature liquid dominated reservoir with temperatures ranging from 300 to 330°C and enthalpy values between 1,160 and 1,860 kilojoules per kilogram. These conditions generate two phase discharge with wellhead steam fractions generally between 30 and 50 percent (Harijoko et al., 2016). Reservoir fluids exhibit moderate salinity, a neutral pH Na Cl composition, and low gas concentrations, with chloride content ranging from 7,500 to 14,000 parts per million and steam phase gas concentrations between 0.3 and 2.3 percent (Layman et al., 2002). The combination of deep hydrothermal heating and active volcanic input creates a thermodynamically rich environment suitable for power generation and potential direct use applications.

Several studies have evaluated thermodynamic performance of the Dieng Geothermal Field using energy analysis and exergy analysis. Exergy availability increased significantly between 2014 and 2023, while second law efficiency showed a declining trend due to conversion losses and operational constraints (Pambudi et al., 2014; Rudiyanto et al., 2021; Kurniawan, 2023). This condition highlights the presence of untapped thermal potential within production wells and surface facilities. One significant source of unused energy is heat loss within the Steam Above Ground System (SAGS). This unused thermal energy represents an opportunity for direct use of geothermal applications.

At the same time, surrounding communities in the Dieng region require substantial quantities of hot water for daily activities, especially for bathing, due to colder highland temperatures throughout the year. This strong and

continuous demand for hot water establishes a natural link between geothermal waste heat availability and community energy needs. The integration of unused geothermal heat with household hot water demand provides a feasible pathway for developing geothermal based district heating in the Dieng Plateau.

1.1 Background

Production wells in the Dieng Geothermal Field exhibit distinct thermodynamic behavior that reflects the characteristics of the underlying reservoir. Figure 1 presents the relationship between wellhead pressure and enthalpy for production wells in the field. The majority of production wells plot near the saturated liquid curve, indicating dominance of liquid phase discharge with relatively high pressure and moderate enthalpy. Only a small number of wells approach the saturated vapor region, demonstrating steam dominated discharge at lower wellhead pressures and higher enthalpy (Kurniawan et al., 2024). These two discharge regimes support different operational roles, with steam dominated wells preferred for electricity generation and liquid dominated wells preferred for thermal energy utilization.

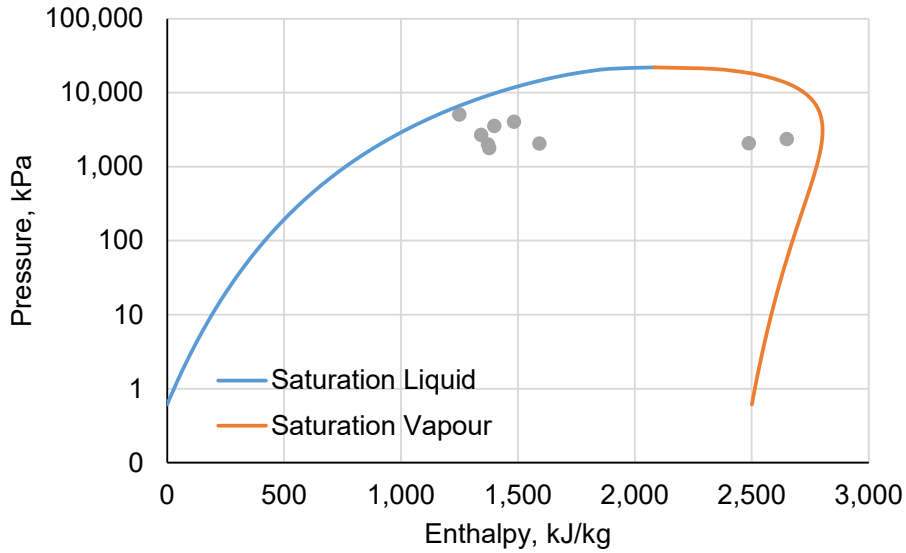


Figure 1. Characterization of production wells in the Dieng Geothermal Field based on wellhead pressure and enthalpy (Kurniawan et al., 2024).

Historical thermodynamic assessments of the Dieng Geothermal Field indicate significant variation in exergy availability across operational years. Exergy increased from 59,518 kilowatts in 2014 to 167,075 kilowatts in 2023 (Pambudi et al., 2014; Rudiyanto et al., 2021; Kurniawan, 2023). However, second law efficiency decreased from values near 36 percent to values near 31 percent. The mismatch between rising exergy and declining efficiency suggests that a portion of available energy remains unutilized due to conversion losses, turbine performance limitations, and operational restrictions. This condition highlights the presence of thermal energy that is not fully incorporated into electricity generation processes.

One significant contributor to unused energy is operational loss within the SAGS. The SAGS transports geothermal steam from production wells to the separator station and onward to the power plant. During transport, steam undergoes pressure reduction due to frictional resistance and elevation changes along the pipeline. These pressure variations promote condensate formation at several points along the pipeline. To protect turbine components from dissolved impurities, bypass lines are opened to divert a fraction of steam and condensate mixture. This operational practice ensures low total dissolved solids entering the turbine but results in intentional release of energy that remains unutilized for power generation. The accumulation of condensate at low elevation points within the SAGS creates accessible thermal resources with stable temperature characteristics. These low elevation points function as natural condensate collectors due to topographic conditions. Condensate arriving from multiple CDP concentrates at these points, producing a reservoir of warm liquid with recoverable thermal energy. This phenomenon presents an opportunity for secondary heat extraction using simple and compact heat exchanger systems. The coexistence of increasing exergy availability, declining thermodynamic efficiency, intentional operational heat loss, and natural condensate accumulation provides a strong rationale for investigating direct use geothermal applications in the Dieng Geothermal Field. These conditions establish a technical foundation for evaluating heat extraction potential from the SAGS and for assessing the feasibility of geothermal based district heating in surrounding communities.

1.2 Energy Demand for Hot Water

The Dieng Plateau is located at an elevation of approximately 2,000 meters above sea level and experiences relatively low ambient temperatures throughout the year. This highland climate creates a strong and consistent demand for heated water in daily household activities, particularly for bathing. A survey conducted in 2024 showed that 82.7% of respondents required hot water for bathing, while 17.3% relied on alternative methods for maintaining comfort under cold conditions (Kurniawan et al., 2024). Figures 2 and 3 present the distribution of energy sources used by households for water heating.

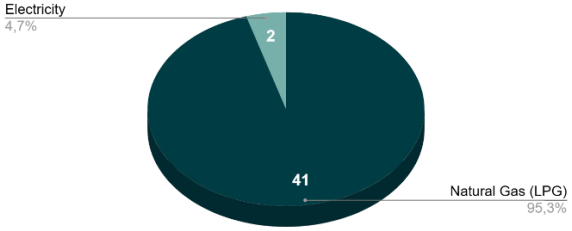


Figure 2. The energy source for providing heat for bathing in Dieng Plateau based on survey 2024 (Kurniawan et al., 2024).

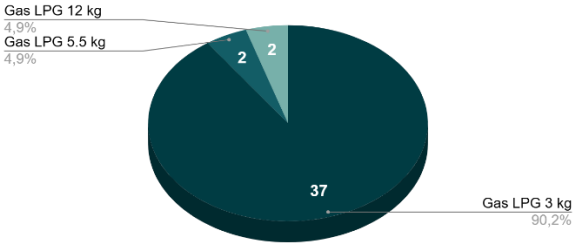


Figure 3. Natural gas types used by respondents who use gas water heaters in Dieng Plateau based on survey 2024 (Kurniawan et al., 2024).

Survey results indicate that Liquefied Petroleum Gas (LPG) represents the dominant energy source for domestic hot water production, with 95.3% of households surveyed relying on LPG water heaters and only 4.7% using electricity. LPG is supplied in several cylinder sizes, most commonly 3 kilograms, 5.5 kilograms, and 12 kilograms. Average household consumption in the Dieng region reaches approximately 11.5 kilograms of LPG per month for water heating. Data from the Indonesian Ministry of Energy and Mineral Resources indicate that one kilogram of LPG contains approximately 11,254 kilocalories of thermal energy. Monthly LPG consumption of 11.5 kilograms is therefore equivalent to approximately 129,558 kilocalories, which corresponds to 150.8 kilowatt hours of thermal energy required to meet the average hot water demand of a household.

Household dependence on LPG for water heating introduces several challenges. High LPG demand increases sensitivity to supply fluctuations, which often occur during peak travel seasons when road distribution networks experience delays. Variability in LPG prices also creates uncertainty in monthly household expenditure because subsidized and non-subsidized LPG carry significantly different price levels. Subsidized LPG in 3 kilogram cylinders is typically priced near Rp 6,000 per kilogram, whereas nonsubsidized LPG in larger cylinders is generally priced near Rp 14,000 per kilogram (Kompas.com, 2025). Based on these price ranges, monthly household expenditure for hot water production reaches approximately Rp 69,000 for subsidized LPG usage and approximately Rp 161,000 for non-subsidized LPG usage.

From an energy policy perspective, the heavy reliance on LPG for domestic hot water production presents broader national challenges. Indonesia imports more than seventy percent of nationwide LPG demand, resulting in significant exposure to international price fluctuations and foreign currency risk. Subsidies allocated for 3 kilogram LPG cylinders also represent a substantial portion of the national energy subsidy budget (IETO, 2024; IETO, 2025). These conditions highlight the importance of diversifying household heating energy sources, particularly in regions with strong geothermal potential such as the Dieng Plateau. The combination of persistent household demand for heated water, high LPG consumption, price variability, and national dependence on imported LPG establishes a clear opportunity for alternative low cost and locally available thermal energy sources. Geothermal heat, particularly low enthalpy heat recovered from CDP along the SAGS, presents a technically feasible and economically attractive option for reducing household reliance on conventional fuels.

1.3 Connecting The Dots

There are two important points that can be connected to the current situation in the Dieng area. The first point is the availability of unused geothermal energy, particularly in the form of heat loss from geothermal operations. The second point is the high heat demand from the surrounding communities, where hot water is required for daily needs such as bathing. Substituting LPG with geothermal energy is technically feasible, as geothermal provides a local energy source that is available 24/7 with a stable supply and significantly lower carbon emissions. Such a substitution would shift energy consumption from fossil fuels to renewable energy, while also

improving energy security through diversification of supply sources. Energy diversity is a critical component of Indonesia's long-term energy security strategy, as it ensures resilience against market fluctuations, geopolitical risks, and environmental challenges.

According to the Indonesia Energy Transition Outlook (IETO, 2024; IETO, 2025), Indonesia's primary energy mix in 2023 was still dominated by fossil fuels, with coal holding the largest share, followed by oil and natural gas. Renewable energy contributed less than 15% of the total primary energy supply, and geothermal represented only a small portion of this share (IETO, 2024). This imbalance highlights the urgency for diversification, especially considering Indonesia's renewable energy targets of achieving 23% by 2025 and 31% by 2050. Heavy reliance on imported fuels, particularly LPG, further increases economic and strategic risks. More than 70% of Indonesia's LPG demand is met through imports (IETO, 2025). This dependency exposes the country to international price volatility, foreign exchange fluctuations, and potential disruptions in supply chains. In addition, it places a large fiscal burden on the government due to the high subsidy allocation for 3 kg LPG cylinders.

Integrating direct-use geothermal applications into the national energy portfolio offers a practical and strategic pathway to mitigate these challenges. District heating systems and community-scale geothermal utilization could directly displace LPG consumption for water heating, thereby reducing import dependency, stabilizing household energy costs, and lowering government subsidy expenditures. Moreover, geothermal direct-use projects support Indonesia's climate commitments, as contribute to greenhouse gas (GHG) emission reductions beyond the power sector. By harnessing residual geothermal heat that would otherwise be wasted, such systems increase overall energy efficiency while simultaneously creating localized energy independence in geothermal-rich areas like Dieng.

2 METHOD

2.1 Resources Availability

The geothermal resource potential evaluated in this study originates from CDP located along the SAGS of the Dieng Geothermal Field. The Dieng Geothermal Field is located in a highland region, and the pipeline alignment follows the natural topography. This topographic condition produces multiple high elevation points and low elevation points that influence condensate formation and condensate drainage along the SAGS. The SAGS extends for more than 5 kilometers, with steam pressure ranging from approximately 13 barg at the separator station to approximately 8 barg near the power plant. The pressure decline corresponds to friction related losses and elevation related losses along the pipeline. As described previously, intentional steam bypassing is applied within the SAGS to reduce total dissolved solids transported to the turbine. The initial bypass flow typically contains a larger proportion of condensate. The bypass flow gradually transitions to steam dominated flow as condensate removal stabilizes operating conditions within the SAGS.

The SAGS in the Dieng Geothermal Field extends across several villages within the Wonosobo area and the Banjarnegara area. The SAGS follows the natural topography of the highland environment, resulting in several pipeline segments that contain distinct low elevation points. These low elevation points frequently occur between two uphill pipeline sections, forming natural condensate accumulation zones along the SAGS. Figure 4 presents several examples of low elevation points within the SAGS pipeline network. Each low elevation point functions as a condensate collection location. Condensate formed along the SAGS flows into CDP located upstream of the low elevation point and is then directed into the condensate collection line. The condensate collection line channels accumulated condensate toward the low elevation point, where the condensate volume becomes sufficiently concentrated for controlled discharge or management. The presence of a low elevation point provides additional value for geothermal resource utilization. A low elevation point can be developed as a centralized heat extraction resource because the collected condensate contains recoverable thermal energy. The continuous arrival of warm condensate from multiple CDP creates a stable thermal source that can support secondary energy recovery systems, such as low temperature heat exchangers or binary working fluid cycles.

This configuration allows the low elevation point to function simultaneously as a condensate management facility and as a potential enhancement to overall field energy utilization.

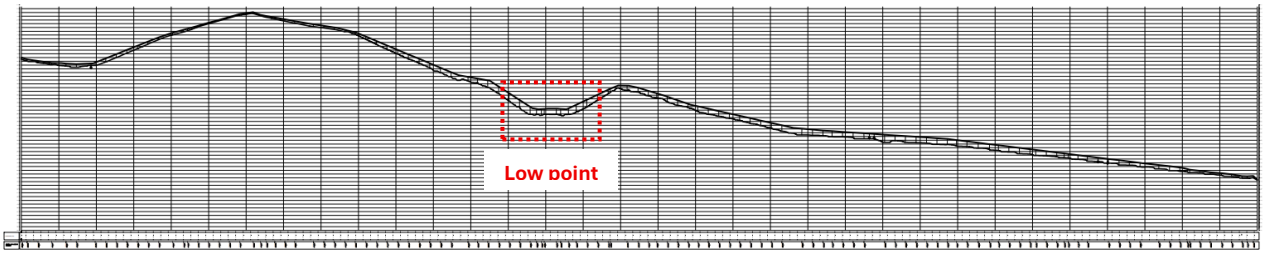


Figure 4. Profile of a low elevation point within the SAGS pipeline network in the Dieng Geothermal Field.

2.2 Heat Extraction Method

For the purpose of this study, the geothermal resource targeted for heat collection is located within a pipeline segment that exhibits an elevation difference exceeding 200 meters. Elevation variation of this magnitude contributes to additional pressure reduction along the SAGS pipeline, and this pressure reduction promotes the formation of condensate within the pipeline segment. The specific extraction location evaluated in this study, designated as CDP J-03, operates at an approximate pressure of 11 barg. Fluid extracted from CDP J-03 undergoes depressurization to atmospheric conditions, producing a significant temperature reduction to approximately 92°C. The resulting flashed steam and condensate mixture forms a viable low enthalpy heat source that can be utilized through a heat exchanger system designed for direct use thermal applications. Figure 5 presents the field testing location associated with CDP J-03. The testing activity at CDP J-03 collects condensate that accumulates along the pipeline segment containing the 200 meter elevation difference. The presence of accumulated condensate confirms the suitability of CDP J-03 as a centralized location for low temperature heat recovery, and the combination of pressure reduction and condensate concentration enhances the feasibility of secondary heat extraction at this point within the SAGS network.

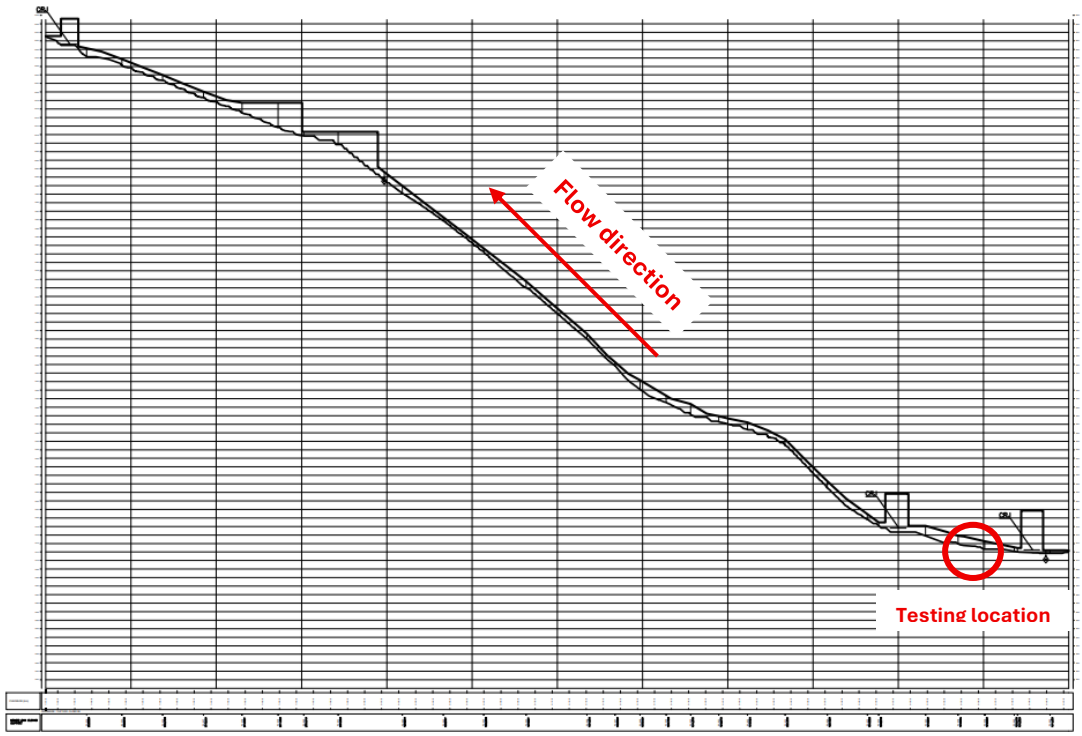


Figure 5. Elevation profile of the SAGS segment showing the testing location positioned at a natural condensate accumulation zone.

The heat extraction process evaluated in this study does not use complex thermodynamic systems or advanced mechanical components. The heat extraction method applied in this study uses a direct heat transfer approach in which thermal energy contained within geothermal steam is transferred to cold groundwater. A shell and tube heat exchanger facilitates the transfer process. Geothermal steam flows through the shell section of the heat

exchanger, while cold groundwater circulates within the tube section. The heat exchanger operates in a counter current configuration. The counter-current configuration increases the LMTD and enhances the efficiency of thermal energy transfer. This arrangement allows geothermal steam to release a substantial portion of available thermal energy before the steam condensate mixture is discharged, thereby improving the effectiveness of low temperature heat utilization.

As illustrated in Figure 6, this study used coiled tubes to improve heat transfer performance. From a heat transfer perspective, present the coiled tubes (Figure 7) which provides a substantial advantage when compared with straight tube geometry. The resulting enhancement produces a higher overall heat transfer rate without requiring a proportional increase in heat transfer surface area. The curvature of the helical coil also introduces additional frictional resistance along the fluid flow path, which results in increased pressure drop. This increased pressure drop necessitates careful operational control to maintain stable flow conditions and to prevent excessive hydraulic losses within the heat exchanger. Based on the heat transfer mechanism associated with the helical coil configuration, the Log Mean Temperature Difference for this system can be expressed using the following Equation 1, 2, and 3.

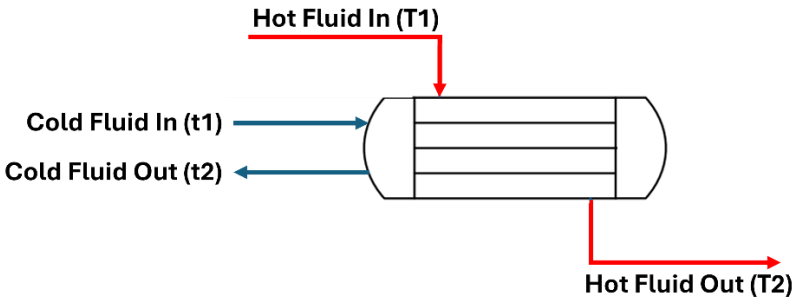


Figure 6. Flow configuration of the counter current heat exchanger used in the CDP J-03 testing, showing geothermal steam entering the shell section and cold water circulating through the tube section.

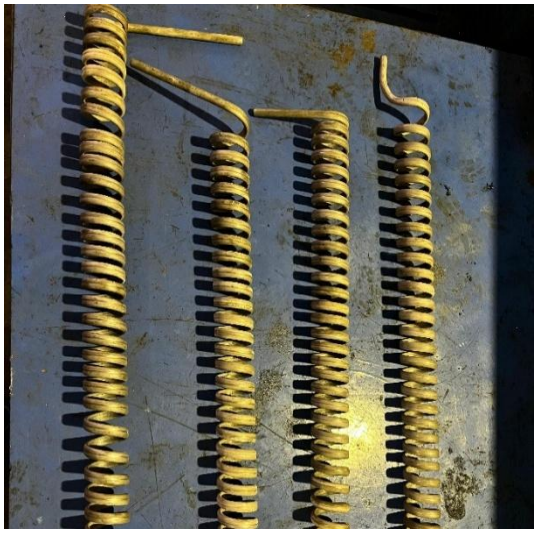


Figure 7. Helical coil tubes employed in the heat extraction system, demonstrating the geometry responsible for secondary flow formation and increased convective heat transfer coefficients

$$\Delta T_1 = T_1 - t_2 \quad (1)$$

$$\Delta T_2 = T_2 - t_1 \quad (2)$$

$$LMTD = \frac{\Delta T_1 - \Delta T_2}{\ln\left(\frac{\Delta T_1}{\Delta T_2}\right)} = \frac{(T_1 - t_2) - (T_2 - t_1)}{\ln\left(\frac{T_1 - t_2}{T_2 - t_1}\right)} \quad (3)$$

The key experimental parameters measured during the testing activity include inlet pressure and outlet pressure of the tube section, inlet temperature and outlet temperature of both working fluids, and cold water flow rate. On the shell section, geothermal steam pressure and temperature were monitored to estimate available thermal energy. Direct measurement of geothermal steam mass flow rate could not be performed because a steam flowmeter was not installed at the CDP. For this reason, several assumptions were required during data interpretation. The primary assumption applied in this study states that the steam fraction entering the shell section remained constant throughout the heat transfer process. This assumption introduces a degree of uncertainty because the steam fraction decreases slightly as heat transfer and condensation occur within the shell section. Additional assumptions were applied during testing, including an assumed inlet temperature of approximately 92°Cfor the working fluid entering the heat exchanger. This assumed value corresponds to the saturated temperature associated with depressurized geothermal condensate collected at the testing location. The experimental setup used in this study consists of a heat exchanger and distribution pump. Cold water is pumped from the water storage tank to the heat exchanger, where cold water absorbs thermal energy from geothermal steam. Heated water produced by the heat exchanger is then collected in open tank.

3 RESULT

The experimental evaluation of the geothermal heat extraction system demonstrated consistent performance under varying flow conditions. The testing activity used a fixed water volume of 5 liters for each trial, and temperature measurements showed that heated water consistently reached values between 84 °C and 86 °C. This temperature stability reflects reliable thermal energy transfer from geothermal steam to circulating cold water within the heat exchanger. The normal flow condition trials produced heating durations ranging from 53.6 seconds to 55.8 seconds. These values indicate that the heat exchanger system delivered uniform thermal output when water circulation occurred at lower flow velocity. The high flow condition trials produced shorter heating durations ranging from 35.3 seconds to 40.1 seconds. The shorter heating duration observed during high flow circulation reflects an increase in the convective heat transfer coefficient within the tube section of the heat exchanger. Higher flow velocity enhances turbulence, reduces thermal boundary layer thickness, and allows a greater fraction of thermal energy to be transferred from geothermal steam to cold water.

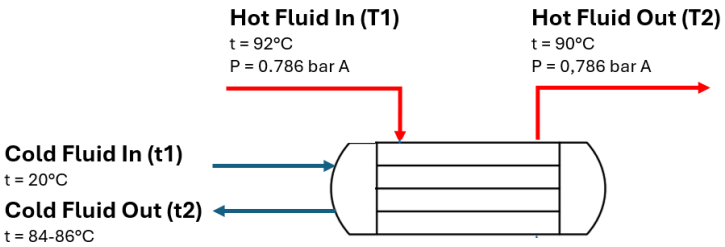


Figure 8. Inlet and outlet temperatures of geothermal steam and circulating water across the counter current heat exchanger during testing

The hydraulic capacity of the circulating system can reach approximately 3 m/s through 1/2 inch pipeline. The geothermal heat extraction system can produce approximately 35.7 liters of hot water per minute at a temperature of approximately 85°C. This production rate is approximately three times higher than the volumetric flow rate of a conventional gas fired water heater with an average hot water capacity of 10 l/m. The thermal capacity of the geothermal system is approximately seven times higher than the thermal capacity typically provided by a conventional gas fired water heater, demonstrating the significant performance advantage associated with direct use geothermal heat extraction. The details of testing results are described in Table 1.

Figure 8 shows inlet and outlet temperature measurements that produce a large temperature driving force between geothermal steam and cold water. This temperature difference supports a high LMTD across the heat exchanger. A high LMTD indicates strong thermal gradients along the exchanger length and enhances energy transfer efficiency. The helical coil configuration strengthens this effect by generating secondary flow patterns that increase overall heat transfer coefficients.

The cold water temperature increases from approximately 20°C at the inlet to 84–86°C at the outlet enables evaluation of the heat transfer rate. With a measured volumetric flow capacity of approximately 35.7 L/min and a temperature rise of approximately 65°C, the thermal output reaches values in the range of several hundred

kilowatts. This thermal capacity exceeds the performance of conventional household gas water heaters and demonstrates the capability of CDP to deliver substantial usable heat.

Table 1. Summary of heat recovery performance obtained from testing at CDP J-03 in the Dieng Geothermal Field.

Test Number	Volume (liters)	Time (seconds)	Temperature Output HE (°C)
1	5	55.8	84
2	5	53.6	85
3	5	54.3	85
4	5	35.3	86
5	5	40.1	85
6	5	38.2	85

Overall, the testing results demonstrate that geothermal condensate and flashed steam at the selected CDP can support continuous hot water production at high volumetric output and stable temperature. The performance characteristics observed during this study indicate substantial potential for scaling the system for various direct use applications such as process heating, space heating, industrial preheating, or district hot water systems.

4 DISCUSSION

The use of geothermal steam and geothermal condensate as a direct energy source represents a relatively recent development in modern geothermal utilization. Several countries have demonstrated successful implementation of this concept in the form of district heating systems, where low enthalpy geothermal resources supply continuous thermal energy for residential and commercial heating networks. The objective of the present trial is to evaluate the potential of geothermal heat from the Dieng Geothermal Field for district heating applications, particularly because the surrounding region exhibits a significant and economically attractive demand for hot water. Further discussion is required regarding key aspects that influence feasibility of district heating development in this region. Two essential considerations are hot water pricing and hot water distribution. Hot water pricing determines economic competitiveness relative to conventional heating technologies, while hot water distribution governs infrastructure requirements, pipeline routing, and overall thermal efficiency.

4.1 Hot Water Pricing

Hot water pricing represents a critical parameter for assessing the feasibility of geothermal based district heating, particularly because alternative energy sources such as gas and electricity remain widely available in the surrounding region. The most accessible benchmark for hot water pricing is the cost of gas fired water heating, and therefore gas consumption data were selected as the primary basis for economic comparison.

The thermal energy examined in this comparison represents only the energy required to increase water temperature for bathing and does not include the cost of the water supply. Based on reported gas consumption values, monthly expenditure for domestic hot water ranges from approximately Rp69,000 to approximately Rp161,000. In energy terms, the same level of hot water usage corresponds to approximately 150.8 kilowatt hours per month. The equivalent energy cost therefore ranges from approximately Rp458 per kilowatt hour to approximately Rp 1,068 per kilowatt hour. To promote geothermal based heating as a competitive alternative, geothermal heat must be offered at a lower cost than gas-based heating or electricity based heating. Economic considerations are not the sole determinant of consumer behavior, but cost remains the dominant driver influencing household decisions regarding heating technology.

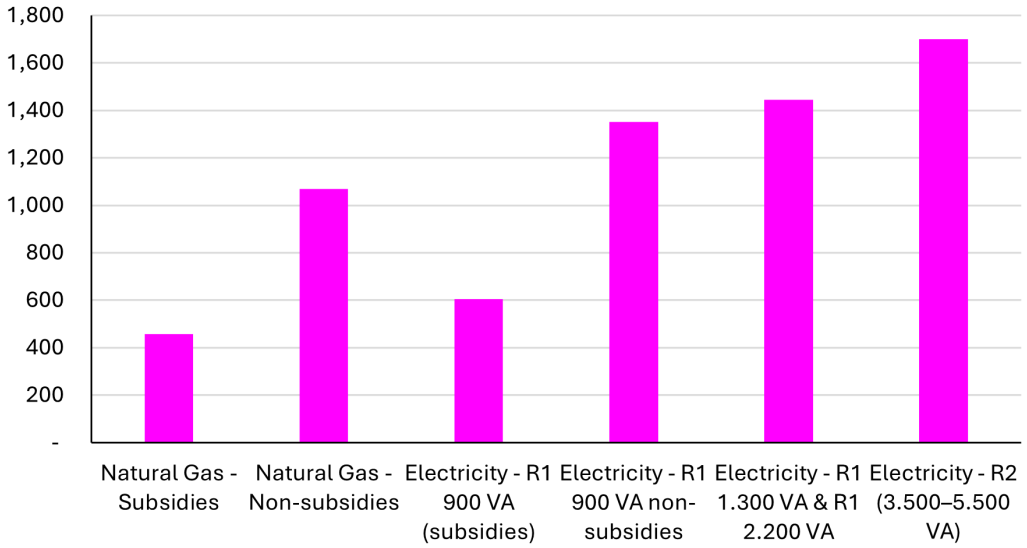


Figure 9. Cost comparison of various energy sources needed to deliver 150.8 kilowatt hours per month of thermal energy for hot water use in the Dieng area

Based on Figure 9, geothermal heated water demonstrates strong economic potential when geothermal heat pricing is positioned below the cost of natural gas-based heating and below the cost of electricity based heating. The comparison shown in Figure 9 indicates that subsidized natural gas presents the lowest cost among conventional alternatives, followed by non-subsidized natural gas and various categories of electricity tariffs. Several electricity tariff groups exhibit significantly higher heating costs, particularly for higher voltage classes, which reinforces the opportunity for geothermal heat to compete effectively in the domestic hot water market.

4.2 Hot Water Distribution

The concept of geothermal-based hot water distribution in the Dieng region can be developed through a model in which the geothermal operator supplies thermal energy, while the final hot water delivery to end users is managed by the local community. In this configuration, the geothermal operator provides heat through a dedicated heat exchanger system connected to the SAGS. Heated water produced through the heat exchanger is stored in a centralized hot water tank that serves as a thermal buffer. Thermal energy delivered to the hot water tank is measured using a thermal energy meter, allowing accurate quantification of geothermal heat supplied to the community.

The local community then distributes heated water from the centralized hot water tank to individual users, including homestay businesses, households, and commercial facilities with constant hot water demand. Community based distribution offers several advantages, including shorter distribution routes, reduced pipeline installation cost, and the ability to respond rapidly to local operational issues. Community level management also supports equitable tariff setting because hot water demand patterns and consumption behavior in the Dieng region are well understood by residents. This model allows geothermal heat to be commercialized without requiring the geothermal operator to manage water infrastructure. Direct heat sales create a clear business boundary in which the geothermal operator sells only thermal energy, while the community manages storage, distribution, and end user interaction. Such an arrangement increases economic feasibility because heat extraction from the SAGS uses waste heat that would otherwise remain unutilized. Centralized hot water storage also stabilizes temperature and ensures consistent thermal supply throughout daily demand fluctuations. Implementation of this model provides an opportunity to introduce geothermal based district heating in a simplified and scalable form. The combination of thermal energy supplied by the geothermal operator and distribution conducted by the community strengthens local involvement, reduces operational complexity, and supports sustainable direct use geothermal development in the Dieng highland region.

5 CONCLUSION

The testing evaluation of heat extraction at CDP J-03 confirms that geothermal condensate and flashed steam available along SAGS in the Dieng Geothermal Field contain sufficient thermal energy to support continuous hot water production at temperatures suitable for residential and commercial demand. The heat exchanger system produced stable outlet temperatures between 84°C and 86°C and demonstrated volumetric production rates of approximately 35.7 L/min, a value significantly higher than the output of conventional gas-based household

water heaters. This consistent thermal performance validates the technical feasibility of extracting low enthalpy geothermal heat using a compact and scalable shell and tube heat exchanger equipped with helical coils. Economic assessment indicates that geothermal based heating becomes an attractive alternative when geothermal heat pricing is positioned below natural gas and electricity prices. The Dieng region presents strong market potential due to high household demand for heated water and limited alternatives capable of providing reliable, cost stable hot water supply. The availability of unused geothermal heat and the magnitude of local energy demand form a practical basis for district heating development. The results demonstrate that geothermal heat extracted from CDP can reduce dependence on imported LPG, which enhance local energy security. A community-based distribution framework supported by centralized thermal storage offers an effective and socially inclusive method for delivering geothermal heat to end users. Wider implementation of this concept can contribute to national energy diversification targets and support long term sustainability in geothermal rich regions such as the Dieng Plateau. Further work involving pilot scale expansion, optimization of distribution hydraulics, and multi season performance evaluation is recommended to prepare for broader geothermal direct use deployment.

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