GEOTHERMAL USAGE FOR HOT WATER SUPPLY - A CASE STUDY IN VIETNAM AND RECOMMENDATIONS FOR GOVERNMENT MANAGEMENT

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Abstract –*Geothermal is a stable, resilient, environment-friendly energy. This energy comes from the earth and can be harnessed for several aims, such as heating, hot water supply, agricultural drying, and electrical production. Because of arising from the earth, the hot water is stable and does not depend on the outside weather. Vietnam has a lot of places where geothermal energy can be exploited to save energy. However, this kind of sustainable energy isn not fully known and used. Moreover, Vietnam has no feasible policy to manage and exploit this energy. In this study, the hot water supply system for the resort in Binh Chau (in the South of Vietnam) was designed and the benefit of this was also concerned. Because the hot mineral water can not be directly supplied, the geothermal-hot water heat exchanger is used, and the code of which was written using the Engineering Equation Solver program. The results show that geo-thermal energy is one of the good manners to reduce the electrical demand, so Carbon Di-oxide emission is also reduced. In addition, policies for geothermal control in other countries are concerned and compared with the current situation in Vietnam. Then recommendations are provided to facilitate further the effective utilization of this sustainable energy in Vietnam.*

Keywords: *geothermal energy, hot water supply, heat exchanger, policy, sustainable energy.*

INTRODUCTION

Fossil fuels (coal, oil, natural gas) are prevalent in producing energy globally. This kind of energy causes the greenhouse effect and will run out in the future (UN Climate change con-ference, 2021). At the COP26 conference, countries committed to reducing CO2 emissions and coal electric power will be phased out after 2030. Therefore, renewable energy is a good choice to replace fossil fuels because this energy does not affect the environment and exists per-manently (Mary and Mario, 2018). Renewable energy comprises solar energy, wind energy, wave energy, tidal energy, geothermal energy, and biomass energy. Geothermal energy originates from the earth's interior and originates from the volcano, thermal phenomena, and the planet's formation. The temperature increases with the increase of the depth of the earth. At a depth of 6000km, the temperature can reach 4200ºC at the planet's core. Geothermal en-ergy can be expressed as a hot spring. A hot spring is a pool of hot water that emerges from the underground. The underground water takes heat from the shallow magma or circulates through the hot deep rock or from the radioactive decay inside the earth; b/ geothermal reservoir where hot water or high-pressure steam is kept. The underground water is heated by the hot rock and creates geothermal reservoirs in the deep earth.

To exploit this water source, we have to dig and pipe directly into this reservoir (Goldstein et.al, 2021). The use of geothermal has some advantages as this energy is steady and is not affected by weather compared with solar energy or wind energy. The lifetime of the geo-thermal well can prolong to 20 years. Moreover, this kind of energy does not affect the environment compared with hydropower and coal power. A large number of the area must be used, and thousands of trees are cut down to build the water receiver, which strongly affects the environment. Using geothermal energy means no CO2 emission occurs and it does not pollute the water source. The geothermal water can be returned to the earth after being used, so the underground water can be saved. However, some toxic gases such as CO2, H2S, and Arsenic…escape from the deep earth when exploiting geothermal energy. On average, geo-thermal power releases nearly 90kg to 120kg of CO_2 per 1 MWh, but this figure is significantly lower than that of coal power. For that reason, geothermal electric power must have a gas monitor to limit these toxic gases. In addition, the underground hot water must be controlled to protest the sinking of land.

There are lots of studies about geothermal energy (Johnston et al., 2011); however, the limited studies on optimal geothermal usage, economics and environment. This study investigates the technology of Enhanced Geothermal Systems (EGS) and Ground Source Heat Pumps (GSHPs) to exploit the geothermal energy and maximize the economic and protect environment. Authors reveal that EGS and GSHPs are important because they can be broadly applied. EGS technology needs further research, but GSHPs technology is widely used at present and policymakers need to be concerned about this (Toni Kraft et al., 2011). Toni Kraft et al. reveal that enhanced geothermal systems (EGSs) are popular, but seismicity risk appears and becomes a challenge to disseminating this technology. Therefore, they overview the ex-periences of Basel, Switzerland, to develop it (Preene and Powrie, 2009). This study pointed out that using underground hot water reduces energy costs and is environmentally friendly. However, the design and performance should be aware of saving energy and avoiding failures. In addition, this study introduces some existing design methods and some potential failures which can occur during operation (İsmail, 2014). Geothermal energy has been used for tourism in Afyonkarahisar city (Turkey). However, with the development of tourists, thermal water management is not good. Inefficient control could cause risks for this natural resource. Therefore, some suggestions were released to protect thermal water from illegal drilling and distribution because the future of this city's tourism strongly depends on geothermal water (Jasmin Raymond et al., 2015). In Canada, geothermal energy is mostly used in heating and cooling buildings and taking baths. The heat pump producing the hot water uses thermal water. Canada's total geothermal heat pump capacity is about 1,458MW, with an annual geothermal energy use of 11,338 TJ. The commercial hot spring, thermal water for bathing and pools are drawn from the hot well with temperatures from 40°C to 57°C and the flow rate from 1 to 30 liters per second. The total thermal power and annual geothermal energy of commercial bathing is 8.8 MW and 277 TJ, respectively. However, the high development of geothermal heat pumps for heating can not be achieved. Jasmin Raymond et al. claimed that the reduction of gas prices since 2008 caused the lower usage of the geothermal heat pump (John, 2016). John Vourdoubas analyzed the energy consumption of hotels in summer in Crete, Greece. The author reported that the average annual energy consumption is about 149 kWh/m2 and 19.4 kWh/p.n.s (per night spent). In addition, the average CO_2 emission for energy-using is nearly 12.1 kg per night spent. Most of the hotels in Crete use renewable energy such as solar hot water, PV cells, solid biomass burning, and geothermal heat pump. With the usage of renewable energy, CO_2 emission sharply reduces. Moreover, the subsidy from the government for renewable energy plays a vital role in energy consumption in this country (Yang, Cui and Fang, 2010).

Yang, H., Cui, et al. investigated the ground-coupled heat pump (GCHP) to draw the heat from the water well and supply this heat to the heat pump. They claimed this system is popular in residential and commercial buildings due to its high efficiency and environment friendly benefits. Moreover, they introduced various GCHPs used in cooling and heating and summarized the detail of heat transfer in this process. They also reviewed various simulation programs for the vertical GCHP in their paper (Wang, Ma and Lu, 2009). Wang, X et al conducted the experiment of a direct expansion ground-coupled heat pump (DX-GCHP) system for heating mode. They studied three U tube copper heat exchangers in three 30m boreholes to supply the heat for the evaporator of the heat pump and the heat pump produced 50°C hot water with a capacity of nearly 6.3kW, the heat pump COP of 3.55 at the evaporator temperature of 3°C and the condensing temperature of 54°C. Moreover, they also investigated the heat extraction from the ground and refrigerant charge and discussed some problems which could be happened in this system.

In Vietnam, about 264 geothermal sites can be harnessed. These sites are located in the North, Middle and the South of Vietnam. Most of the geothermal energy is used for bathing and agricultural drying. Recently, the authority in Quang Tri province (the Middle of Vi-etnam) has adopted to build geothermal power with a total capacity of 25MW. The well-known hot spring in the South of Vietnam is Binh Chau, Ba Ria province in the South of Vietnam. Binh Chau, a well-known tourist in Vietnam, has beautiful hot springs and some thermal ponds whose water temperature ranges from 40oC to 82oC. The hot mineral water has been used for bathing and medical treatment. In this area, there are a lot of hot wells that can boil eggs and excite tourists.

In this paper, the hot water supply system using geothermal hot water was designed and the economy was also assessed. The hot water distributes to rooms, kitchens and health care areas for bathing and a steam bath. Because of being mineral water cannot be directly used, the geothermal water-hot water heat exchanger was designed. Then, current policies of thermal usage for tourism and electricity production will also be elaborated not only in Vi-etnam but also in other nations before reasonable recommendations are provided to over-come shortcomings in the Vietnamese legal system.

METHODOLOGY

This study employs a combination of quantitative and qualitative methods to determine the economic value of geothermal utilization in Vietnam, followed by recommending legal policies for management. In relation to the quantitative method, the study utilizes a scenar-io-based approach to select a specific area in Vietnam. To gain an accurate understanding of the economic benefits of this heat source, particularly in the tourism sector and natural hot springs, the study also uses a heat exchanger must be designed to increase the water tem-perature (refer to Figure 1) and and apply them to the selected area. Based on the obtained empirical results, the study will provide an overall economic assessment and develop ap-propriate legal policies for efficient utilization of this energy source in Vietnam. Specifically, the study will employ qualitative approaches, including the legal comparison and doctrinal method to address the identified issues.

The steps for this research are conducted as below:

Step 1: Calculate the amount of water demand for hotel

Step 2: Design heat exchanger.

Step 3: Analyse the economic system.

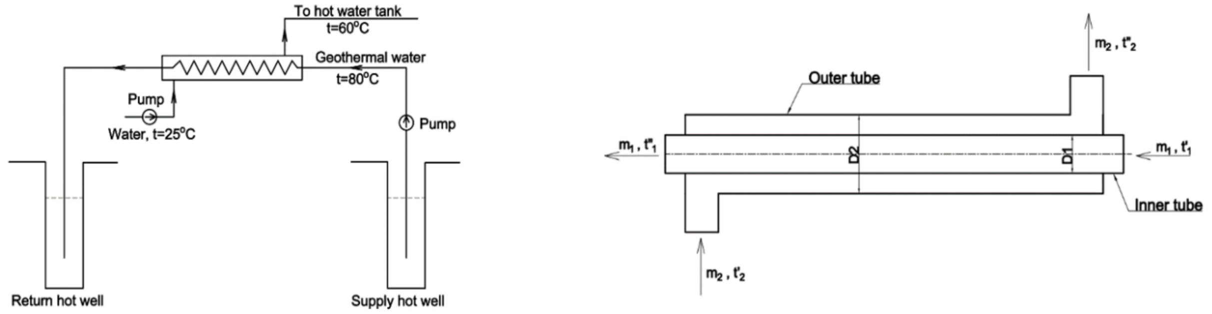
Step 4: Legal recommendations for govermental policies.

RESULT AND DISCUSSION

1. The design of hot water supply and economic analysis.

1.1 Hot water flow rate and the heat power of equipment.

The 100 rooms resort was supplied with hot water that is produced by geothermal energy. Because geothermal water can not be directly used, the geothermal water-hot water heat exchanger is used. This heat exchanger is the counter-flow tube in a tube. The diagram for hot water distribution and the counter-flow heat exchanger are displayed in figure 1.



(a) (b)

Figure 1. The diagram of hot water distribution (a), the counter-flow heat exchanger (b).

The geothermal water is piped from the hot well of 80°C(t'_1) and pumped through the geothermal water-hot water heat exchanger with the flow rate m_1. The heat exchanger takes the heat from the geothermal water and transfers it to the cool water with a flow rate m_2. After leaving the heat exchanger, the geothermal water with temperature (t''_1) returns to the hot return well to pre-serve the water source and the cool water temperature rises from t'_2=25°C to t''_2= 60°C.

Following this, the daily water consumption for rooms is 56.8 l/unit, so the total flow rate for 100 rooms is 5680 liters per day. If the operating hours to produce the hot water per day are 8 hours, the water flow rate production is 710 l/h. The other water demands in the kitchen, club, the gymnasium, calculated and summarized in table 1.

Table 1. The household electrical demand.

Equipment	Water demand (l/h)	Number of fixtures	Demand factor	Probable demand (l/h)
Dishwasher	300	3	0.25	225
Kitchen sink	114	4	0.25	114
Laundry, station tub	106	1	0.25	26.3
Shower	850	4	0.4	1360
Lavatory	30	2	0.4	24
Total				1749.3

The total hot water demand of the resort is V=2459.3 l/h. This is the amount of hot clean water which needs to be produced. Following (Yunus, 2002), the energy balance between geothermal water and cool water in the heat exchanger is displayed in Eq(1).

$$Q=m_1.Cp_1.(t'_1-t''_1)=m_2.Cp_2.(t''_2-t'_2) \qquad (1)$$

The relationship between volume flow rate and mass flow rate is expressed in Eq(2).

$$m=V.\delta \qquad (2)$$

Follow Eq(1),Eq(2), the mass flowrate for geothermal water and hot water demand are m_1=0.7 kg/s, m_2=0.683 kg/s, respectively. The heat power to produce the hot water is 114198 (W), the flow rate of geothermal water should be chosen to save this water and the relationship between geothermal water flow rate (m_1) and the outlet temperature (t''_1) is displayed in figure 2.

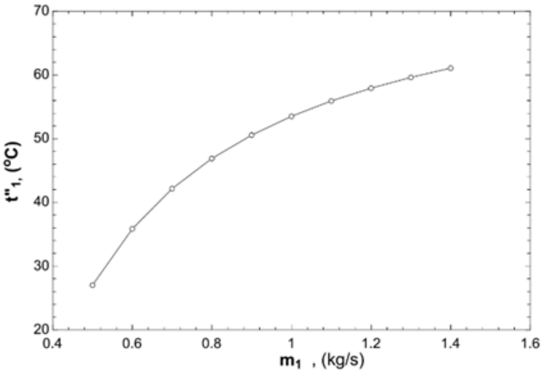


Figure 2. The relationship between geothermal water flow rate and outlet temperature.

It is clear that the increase in the geothermal mass flow rate causes an increase in the outlet temperature. With m_1=0.5 kg/s, the outlet temperature t''_1=27°C, the lower mass flow rate usage will save up the geothermal water, the pump energy, and the pipe system but having the large heat exchanger. Therefore, geothermal water of 0.7 kg/s was chosen, leading to the outlet temperature of 42.15°C.

1.2 The design of tube inside the tube heat exchanger

The heat exchanger code was designed using EES (Engineering Equation Solver) software. With geothermal mass flow rate m_1=0.7 kg/s, hot water demand m_2=0.683 kg/s. The material of the heat exchanger is Steel with thermal conductivity k=43 W/m.K. The cool water with m^2=0.683 kg/s flows inside the annular area with the outer tube having an outside diameter D_2 and the inner tube with an outside diameter D1 (figure 1b), the geothermal water flows inside the inner tube with an outside diameter of D1, both of tubes have the thickness of 0.5mm. The ratio of D_2 to D_1 is 2 and the D_1 and D_2 were chosen by pressure drop, convection heat transfer coefficient, the total length, etc. The codes were written based on these heat transfer equations.

The total heat transfer coefficient of the heat exchanger U (W/m^2.K):

$$U=\frac{1}{\frac{1}{h_1}+R_F+\frac{t}{k}+\frac{1}{h_2}} \qquad (3)$$

h_1 is calculated using the function of EES software:

Call pipeflow ('water',T_1,P_1,m_1,D_1_i,L_1,RelRough_1:h_T_1, h_H_1 ,DELTAP_1, Nusselt_T_1, f_1, Re_1).

h_2 is calculated using the function of EES software:

Call annularflow ('water',T_2,P_2,m_2,r_i, r_o,L_2,RelRough_2:h_T_2, h_H_2 ,DELTAP_2, Nusselt_T_2, f_2, Re_2).

The fouling factor of RF=0.000528 m^2.C/W, the 0.5 mm thickness of the pipe and the 0.005 relative roughness of the tube was chosen for this calculation. Using these functions, the Nusselt, Renold, convection heat transfer coefficient (h_H_1, h_H_2), pressure drop (DEL-TAP_1, DELTAP_2), pressure drop coefficient (f_1, f_2) will be found out, at well.

The capacity rate C_1, C_2 (W/°C) of geothermal water and cool water, respectively, are calculated using Eq(4,5):

$$C_1=m_1.Cp_1 \tag{4}$$

$$C_2=m_2.Cp_2 \tag{5}$$

The maximum possible heat transfer rate in the heat exchanger is:

$$Q_{max}=C_{min}.(t'_1-t'_2) \tag{6}$$

The effectiveness of the heat exchanger is:

$$\varepsilon=\frac{Q}{Q_{max}} \tag{7}$$

The number of transfer units NTU is expressed as:

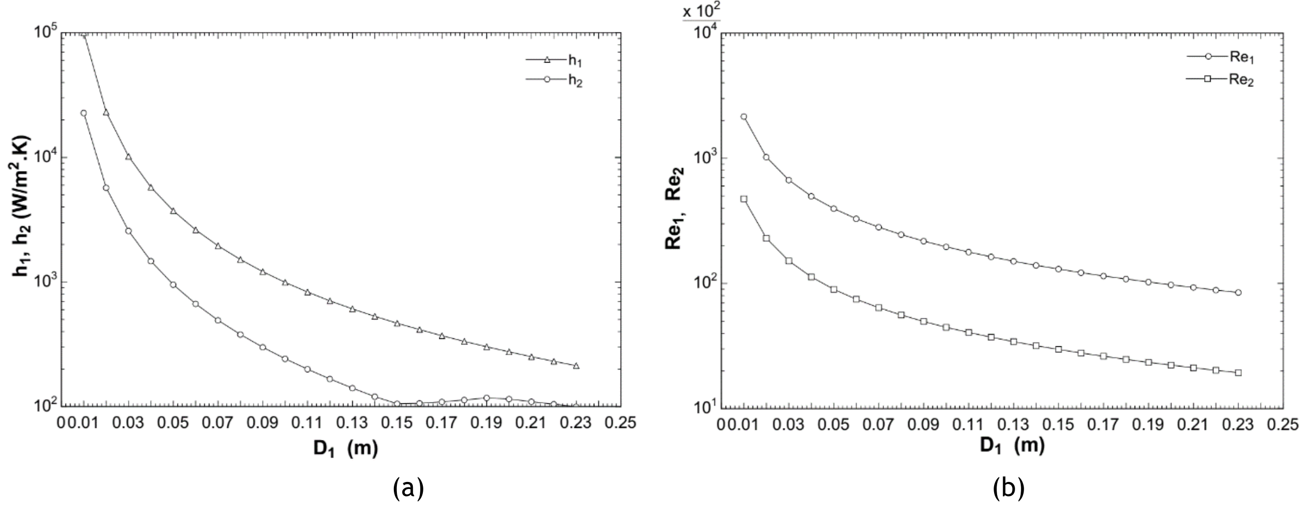
$$NTU=\frac{U.A_S}{C_{min}} \tag{8}$$

NTU is found using the function in EES: hx('counterflow', epsilon, C_1, C_2, 'NTU').

The total length of the heat exchanger is calculated in Eq(9).

$$A_S=\pi.D_1.L \tag{9}$$

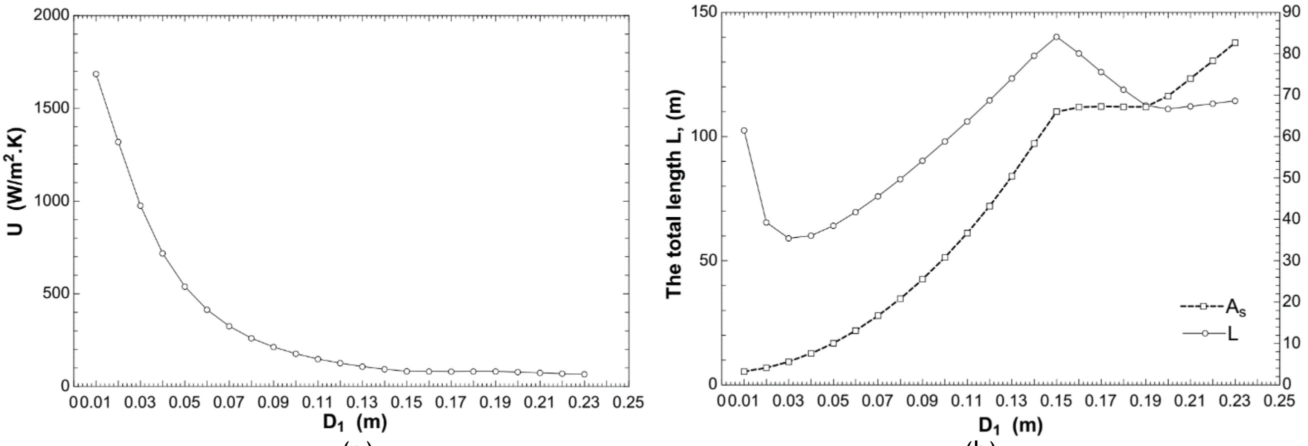
The ratio of D2 to D1 was 2. After calculation, the NTU of this equipment is 1.899, the relation between the outside diameter of the inner tube D1 and the convective heat transfer coefficient, Renolds number, is displayed in figure 3.



(a) (b)

Figure 3. The relationship between D1 and: (a) convective heat transfer coefficients; (b) Renolds number.

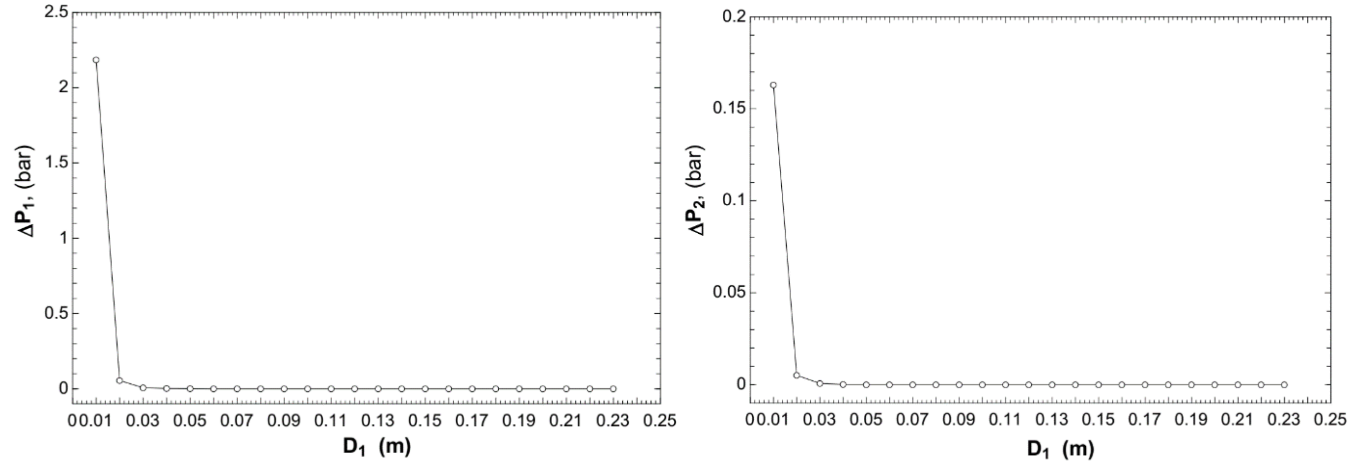
It is clear that the heat transfer coefficient, and the Reynolds number of geothermal and cool water experience a downward trend. These figures considerably drop with D1 from 0.01m to 0.04m. The small diameter increases the fluid velocity, increasing the Reynolds number and convective heat transfer coefficient. The Renolds number of the geothermal water flowing inside the tube (Re_1) is from 3 to 4 times higher than the hot water flow of the annular tube (Re_2) and the heat transfer coefficient has the same trend as the Renolds number because the heat transfer coefficients and the Renolds number are proportional to velocity. The total heat transfer coefficient, the heat transfer surface and the total equipment length were calculated and shown in figure 4.



(a) (b)

Figure 4. The relationship between D1 and: (a) the total heat transfer coefficient; (b) Surface area and total length.

The total heat transfer coefficient U sharply drops with D_1 from 0.01m to 0.06m, rapidly goes down with D_1 from 0.07m to 0.12m and gradually declines with D_1 from 0.13m to 0.15m. The U value slightly goes down with D_1 from 0.15m to 0.23m because the larger diameter makes the fluid velocity slow, leading to the reduction of U. The highest U value causes the lowest heat transfer surface area As because As is inversely proportional to the U value. As enormously climbs with D_1 from 0.01m to 0.15m, but the total length L is lowest with As=5.562m^2, D_1=0.03m, U=974.9 W/m^2.K, at L=59m. After that, with D_1 from 0.15m to 0.19m, the As slightly increases and the total length L also drops in this range. The maximum L is equal to 140m with D_1=0.15m and A_s=66.02m^2. However, to choose the appropriate diameter D1, apart from the total length, the pressure drop is also considered because it causes a high operation cost. The pressure drop per one meter of geothermal water ΔP_1 and cool water ΔP_2 was estimated and depicted in figure 5.



(a) (b)

Figure 5. The relationship between D1 and: (a) geothermal water; (b) cool water.

It was clear that ΔP1 and ΔP2 sharply fall with D1 from 0.01 m to 0.02 m, and considerably reduce with D1 from 0.02m to 0.03m. At D1 from 0.04m to 0.23m, the pressure drop is minimal. The enhancement of pressure drop due to the small area, in addition the area is reversely proportional to fluid velocity and pressure drop. The high fluid velocity also makes the total heat transfer coefficient high and causes the lower surface area A_s, but the high-pressure drop will enhance the operation energy.

With the above parameters, the geothermal water-cool water heat exchanger was chosen with D1=0.05m, D2=0.1m, U=538,4 W/m2.K, L=64.11m, A_s=10.07m2, ΔP1=0.0005227 (bar/m), ΔP2=0.00005977 (bar/m). This heat exchanger could produce the hot water flow rate of V_2=2.46 m^3/h with geothermal water of V_1=2.52 m^3/h. Assumed that the total pressure drops of the geothermal water and the cool water (comprises of heat changer pressure drop, pipe system friction loss and local loss, valve, level difference, etc.) are H=40mH$_2$O and H=30mH$_2$O, respectively. With η=70% and pressure loss, the power of pumps is calculated below.

$$N_{pump} = \frac{\gamma.V.H}{1000.\eta} \qquad (10)$$

With Eq(10), The pump power of geothermal water and cool water is 392W and 287W, respectively.

1.3 The Economics of System

The initial investment cost is estimated and itemized in table 2.

Table 2. The initial investment cost of the hot water system.

Equipment	Cost (USD/unit)	Unit	Price (USD)
Heat exchanger	2500	01	2500
Pump	300	02	600
Pipe system	6000	01	6000
Labor cost	2000	01	2000
Total			11,100

Following Eq(1), the heat power to produce water is 114198 (W),. In terms of using electricity, the total electric energy used to create hot water per day is estimated and summarized in table 3.

Table 3. The electrical energy to produce hot water.

Equipment	Power (kW)	Hour	Power per day (kWh)
Heater	114,2	08	913.6
Pump 1	0.392	08	3.1
Pump 2	0.287	08	2.3
Total			919

From Vietnam Electricity (EVN) (Vietnam Electricity, 2023), the electric price is 2,834 VNĐ (0.128USD/kWh). The monthly and annual electrical costs are 3646.6 USD and 42924 USD.

As for using geothermal hot water, the electric energy is only for two pumps, so the daily and annual energy cost is 0.69 USD and 252.3 USD, respectively. Therefore, the savings, after subtracting the energy cost, amount to 42,672 USD per year. Withthe initial investment cost is 11,100 USD; the payback time is only 94 days.

Clearly, the benefit of geothermal energy is too high, but the geothermal water flow rate is high. During 8 hours of operation per day, 20.2 m^3 of geothermal water must be exploited to heat the cool water, so it must be returned to the earth to conserve this natural resource. Therefore, it is necessary to have some policies that haven’t existed in Vietnam and some policies are discussed in this paper below.

2. Analysis of geothermal energy policy in Vietnam.

2.1 The Current Shortcomings of the Vietnam Government in Policy Implementation Process of The Use of Geothermal Energy.

Vietnam is considered a country with average geothermal potential compared to the world. According to recent surveys, Vietnam currently has about 264 hot springs and sources located across the country, such as Kim Boi (Hoa Binh), Thach Bich (Quang Ngai), and Binh Chau (Ba Ria - Vung Tau), with an average temperature of 70-100oC at a depth of 3km (M.T, 2020). These heat sources can establish power plants ranging from 3 to 30MW. More specially, the area from Quang Binh to Khanh Hoa, which includes geothermal sources with temperatures from 70-150°C, is considered to have great potential for building geothermal power plants for electricity exploitation with a total capacity of about 200MW and tourism development (M.T, 2020).

Nonetheless, Vietnam has not issued a specific policy to maximize the benefits of geo-thermal energy for society and facilitate investment. This stems from the following four main reasons. Firstly, the surveys for geothermal exploitation lack accuracy and the assessment methodology is unreliable (Yasukawa, 2017). In Vietnam, many studies have identified high heat flow in the ground in many locations, providing rich geothermal resources for the ca-pacity to generate electricity. However, these data cannot provide enough evidence for the necessary arguments which support the widespread dissemination of solutions for this re-newable energy development. While other countries in ASEAN, such as Indonesia and the Philippines, make good use of geothermal energy via regular surveys, Vietnam currently fails to have a scientific basis and a specific assessment of geothermal energy. Second, geothermal resources in Vietnam are scattered. Currently, the locations of geothermal resources are not collective and evenly distributed across the country (Yasukawa, 2017). This helps localities approach geothermal energy more efficiently. However, because of the small scale and fragment of the location of geothermal resources, the government is having difficulty attracting investment to construct large-scale and concentrated geothermal plants.

Third, Vietnam has only a few basic geothermal applications, such as drying agricultural products, bathing, hot swimming pools, iodized salt making, animal husbandry, medical treatment, and mineral water bottling (Yasukawa, 2017). Meanwhile, investment in electricity production and tourism from geothermal energy is the potential for the economic develop-ment of many countries, which has not been considered under governmental policies in Vietnam. The Vietnam Institute of Science and Technology (VAST) researched the possibility of electricity generation from geothermal sources, but there has been no development on any power generation projects. The Institute of Geology - Minerals also failed to cooperate with a large US company to convert heat in the ground into electricity because electricity from geothermal sources is much higher than the standard electricity price. In 1995, ORMAT Inc. built a project which failed to produce 50 MW of electricity from potential geothermal locations, including Bang (Quang Binh), Mo Duc (Quang Ngai), Hoi Van (Binh Dinh), Tu Bong, (Khanh Hoa). This is because the cost of technology applications on geothermal energy is relatively expensive compared to other renewable energy (solar and wind energy), ranging from 1.500 to 3.000USD/kW). Moreover, the renovation of geothermal locations for tourism is still limited, failing to attract tourists and lacking competition with other resorts such as Binh Chau in recent years.

2.2 The Successful Experience of Some Countries in The Development of Strategies in The Use of Geothermal Energy.

Many countries in the world have effectively utilized geothermal energy sources for production activities. This arises out of an appropriate legal and policy mechanism of the Government in facilitating the project development. More explicitly, counties with high ge-othermal energy development aim to provide legal mechanisms related to governmental subsidies and electricity pricing. Take Indonesia as a typical example in ASEAN. Indonesia is one of the countries with the largest geothermal resources, ranked 2nd of the world's largest geothermal energy-producing countries, and it keeps the leading position in ASEAN (Wah-josoedibjo and Hasan, 2018). The country currently accounts for approximately 40% of the worldwide amount. Up till now, 325 geothermal prospects have been detected by the government of Indonesia. Herein, there are over 90 geothermal work areas under exploration and operation. To attract more investors in geothermal energy plants and provide an adequate legal framework, the government of Indonesia enacted Law No. 27/2003 on Geothermal En-ergy along with Government Regulation (GR) No. 59/2004 amended GR No. 70/2010 (Wah-josoedibjo and Hasan, 2018). According to the new regulations, the central government is responsible for preliminary investigation determining geothermal sites for a tender while the local agencies undertake the tendering process. Private businesses can survey at their own expense and risk for bidding. The winner is chosen via technical and financial capabilities with the lowest electricity price for bidding. Ten years later, the government issued the new law No. 21/2014 on Geothermal with Government Regulation No. 7/2017, which overcome obstacles in developing the geothermal investment. Specifically, the new law identifies geothermal as an energy process but not mining activity as previously, facilitating the expansion of future geothermal projects. Moreover, the new law allows the government to provide insurance mechanisms and a budget of up to 280 million USD for reducing risks in the exploi-tation process. Finally, to avoid complexities and time-wasting in the issuance of permits and licenses, the new law stipulates the one door policy and reduces the number of requirements in investment.

Along with the governmental subsidies, the government provided a special and low ceiling price and FIT concepts under Minister EMR Regulations No. 48 and 50/2017 (Ministry of Energy and Mineral Resources, 2017). In addition, these regulations updated financial terms and business schemes to manage effectively and attract more investment. Specifically, the depreciation of projects is extended to 20 years instead of 8 years as previously; Take-or-pay should terminate after the investment is completed; Replacement of directors and commissioners needs confirming by Minister EMR (Ministry of Energy and Mineral Resources, 2017).

Along with the use of geothermal energy for electricity production, tourism development is another major advantage investors are concerned about. Yellowstone and Hawaii Volcanoes National Park in North America are famous attractions that millions of people visit yearly. Moreover, the Tongariro National Park in New Zealand and, the Fuji-Hakone-Izu National Park in Japan are also ideal destinations for tourism, which are reputable for volcanic landforms as well as relevant geothermal aspects. This proves that many nations in the world have active volcanic regions and hot springs to attract more tourists for marketing objectives. Take Japan as a typical example of tourism development via geothermal energy. There is a myriad of geothermal spring systems in Japan situated in a volcanic area called the Pacific Ring of Fire. More than 25.000 hot spring sources currently use geothermal power to heat about 2.5 million liters of water per minute (Masuhara and Baba, 2017). These hot springs are considered one distinctive culture which played a crucial part in the life of Japanese people throughout history. Even the government of Japan believes that hot springs are primary re-sources for tourism development and bring substantial economic contributions to the community (Masuhara and Baba, 2017). Unlike Indonesia, the government of Japan and the Jap-anese people advocate the development of hot springs instead of electricity production. The rules relating to the procedure of drilling geothermal wells are stipulated under the Hot Spring Law (Kubota et al., 2013). Specifically, investors need to be agreed upon by the nearby hot spring managers and get a permit to drill the geothermal wells and develop hot springs. Herein, the approval authority belongs to prefectural governors though geothermal power development is a national policy. From 2016 to the present, the Japanese government has provided rules conserving hot springs and natural parks from the negative impacts of geothermal plants on the supply and quality of water. Recently, new insurance policies have been issued to overcome the risks experienced by hot spring communities in geothermal development (Kubota et al., 2013).

Meanwhile, regarding the use of geothermal power for generating electricity, merely 18 geothermal energy plants are currently operated in Japan, which produce 0.3 % of total do-mestic electricity production (Kubota et al., 2013). At present, the government of Japan rec-ognizes the potential of geothermal energy in electricity production via international coop-eration and research. Thus, the government also facilitates investors to participate directly in geothermal plants for electricity production via FIT prices and subsidies. However, the belief of Japanese people is still conservative about the cultural value of hot springs, and they op-pose the detrimental impacts of this activity on natural landscapes (Kubota et al., 2013).

2.3 Recommendations for The Government of Vietnam in The Development of The Use of Geothermal Energy.

Based on Indonesia's drastic growth in geothermal energy for electricity production and tourism, the government of Vietnam needs to learn about the neighboring nations' experi-ences for positive future changes.

First, according to Decision No. 2068/QD-TTg dated November 25, 2015, the Prime Min-ister approved Vietnam's renewable energy development strategy for 2030, with a vision to 2050 stated the orientation: Exploit and maximize the potential of renewable energy in the country with advanced technologies, increase high economic, social and environmental efficiency, facilitate the potential for research, development, transfer, and application of new forms of renewable energy (Yasukawa, 2017). Compared with solar and wind power, the ex-ploitation of geothermal energy in Vietnam is still fresh. Therefore, researchers seem not to be interested in this area. To deal with this shortcoming, the government of Vietnam should provide policies that create a more favorable environment to attract more research (Hoang et al., 2019). Specifically, the central authority, especially the department of trade and industry, should thoroughly understand geothermal energy's role and advantages in the national economy. Thereby, regulations shall be provided to support and fund the research of scientists and specialists, proving geothermal energy's efficiency in daily life. To guarantee the success of studies, the central authority should be willing to equip advanced technology to record more accurate data and save time and effort. In higher education, the government should invest and encourage training subjects regarding geology and energy to stimulate scientific activities and increase high-qualified human resources in the area.

Second, the government of Vietnam needs to improve the legal framework for utilizing geothermal energy as soon as possible. The current provisions for renewable energy in Vietnam fail to support sufficiently for facilitating commercial geothermal energy projects. Currently, the principal legal documents on geothermal power include the Law on Electricity and Law on the Economic and Effective Use of Energy 2010 and other relevant guiding documents. Regarding the feed-in tariff price, until now, Vietnam has only enacted bylaws documents to provide supporting mechanisms in the investment of wind and solar energy projects. Moreover, there is no pricing policy for using geothermal power for electricity production in Vietnam, an enormous hindrance for foreign businesses and investors in geothermal power projects (Hoang et al., 2019). To encourage investment in geothermal energy development, the government should promulgate two mechanisms. The first one is that capital subsidies and soft loans need to be combined to lessen the high-risk profile of ex-ploiting geothermal energy at the beginning (Yasukawa, 2017). Besides, fiscal benefits and one door policy should be provided to support investors and facilitate the feasibility of geothermal power projects, including the exemption of tax, import duty, and land levy, the simpli-fication of procedures in the permit or license approval (Yasukawa, 2017). The second one is that electricity pricing for geothermal power should be documented in detail and provided as early as possible for investors to determine possible strategies and make project decisions. The importance is the price of purchasing electricity should be reasonable and stable for a long time with different criteria. Moreover, the policy needs to be applied synchronously via the management levels from the central to the local authority.

Third, there have been active hot springs in Vietnam for a long time, known as ideal destinations for foreign and domestic tourists, such as Binh Chau, Kim Boi, Bang, Dam Rong, and Than Tai. However, illegal human activity and low awareness have increasingly caused detrimental impacts on the beauty of these hot springs and the water quality. Therefore, the government needs to impose stricter sanctions on violations against the protection of the environment and natural landscapes. Simultaneously, the government of Vietnam should facilitate investors in developing these attractions and lessen the procedures of permit ap-proval for the renovation of hot springs in Vietnam. Besides, the prospects of hot springs should be further invested for research and future exploitation.

Eventually, the government should collaborate with experts or international organizations from other nations with significant geothermal development via bilateral and multilateral agreements. The government of Vietnam has agreed to work with other countries to identify and implement measures to increase the value of geothermal energy in electricity production, tourism, and decarbonization worldwide. Especially, in ASEAN, Vietnam needs to have discussions with other member states with the most significant development of geothermal power plants and tourism, such as Indonesia and the Philippines. By doing this, the government of Vietnam may learn from its experiences in delivering more prompt and pre-cise policies for exploration and the applicability of advanced technology and research. Sim-ultaneously, via close cooperation, Vietnam has more opportunities to introduce strategies for national geothermal power development and tourism areas and attract more foreign inves-tors, tourists, and developers in the future.

CONCLUSION

From what is mentioned, the study has led to some following conclusions. The hot water demand was 2.46 m^3/h, produced by geothermal water with 2.52 m^3/h. To reduce the operation cost, the study chose the outer pipe $D_2=0.1m$ and the inner pipe $D_1=0.05m$. The total length of the heat exchanger is 64.11m, along with two selected pumps, including $N_1=392W$ and $N_2=287W$, respectively. The annual saving energy cost is 42,672 USD per year and 44 payback days. Therefore, to some extent, the study shows that geothermal energy is ideal and cost-effective for a national economy. In Vietnam, despite the potential for exploiting this power, the government is silent to provide no clear mechanism for attracting investment and approving projects of electricity production and tourism development. From the successful experiences of Indonesia and Japan in the development of a legal framework for the use of geothermal energy, Vietnam needs to recognize the current challenges and further undertake the following actions: ensure strategies of development and facilitate research, creating more favorable policies on investment and renovation, building international cooperation with other countries.

Nomenclature.

D_1: the outside diameter of the inner tube, (m).
D_2: the outside diameter of the outer tube, (m)
m_1 : the mass flow rate of the geothermal water, (kg/s).
m_2: the mass flow rate of the cool water, (kg/s).
Cp_1: the heat-specific capacity of the geothermal water, $Cp_1=4310$ (J/kg.K).
Cp_2 :the heat-specific capacity of hot water, $Cp_2=4181$(J/kg.K).

t'_1 : the temperature of geothermal water inlet,(°C).

t''_1 : the temperature of geothermal water outlet, (°C).

t'_2: the temperature of the cool water inlet, (°C).

t''_2 : the temperature of cool water, (°C).

Q: heat power, (W).

V: volume flow rate, (m^3/s).

δ: density of the fluid, (kg/m^3).

h_1: convection heat transfer coefficient of geothermal water flowing inside the inner tube, ($W/m^2.K$).

h_2: convection heat transfer coefficient of cool water flowing inside the annular area, ($W/m^2.K$).

R_F: fouling factor.

t: thickness of pipe (t=0.0005m).

k: thermal conductivity of steel pipe, (k=43 W/m.K).

C_1, C_2 : the capacity rate of the geothermal water and cool water, respectively, (W/°C)

C_{min} is the minimum capacity rate between C_1 and C_2.

Q_{max} : the maximum possible heat transfer rate in the heat exchanger.

ε: the effectiveness of the heat exchanger.

NTU: the number of transfer units.

A_s: the heat transfer surface area of heat transfer, (m^2).

ΔP_1: pressure drop of geothermal water in the heat exchanger, (bar).

ΔP_2: pressure drop of cool water in the heat exchanger, (bar).

L : the length of heat exchanger.

γ: the specific weight of water, (9810 N/m^3).

H:head pressure of pump, (mH_2O).

η: efficiency of pump.

N_{pump}: the power of pump.

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