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Analysis of Potential Utilization of Sarulla Geothermal Combined Cycle Residual Fluids for Direct Use in The Coffee Industry

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ABSTRACT

The Geothermal Power Plant is one of the new renewable energy power plants. In Indonesia, the realization has reached 2%. Sarulla Operations Limited is the first geothermal power plant in Indonesia, located in North Tapanuli Regency, that utilizes combined cycle technology. Coffee is the leading commodity in the North Tapanuli district, with a plant area of 17,586 hectares. Coffee is dried in the traditional way (open field drying) so that it is still constrained by rain and cloudiness and can only be done during the day. The reinjection well fluid has a temperature of 103°C with a flow rate of 4978 t/h and a pressure of 6–14 Bar. This study analyses the residual fluid energy for coffee drying purposes. Energy and exergy calculations are done manually and using DWSIM software with a total of 24 data points 24 hours a day to represent the availability of dryers both day and night. The results showed that the most energy needed to raise the drying air temperature at night from 15°C to 60°C was 125.62 kW, while the lowest energy needed to raise the drying air temperature during the day from 30°C to 40°C was 27.92 kW. The results of research calculations show the energy potential for residual fluid from geothermal plants to be used for drying coffee for 24 hours, both day and night.

1. INTRODUCTION

The application of anaerobic digestion (AD) in GPP (Geothermal Power Plant) is one of the new renewable energy power plants. Geothermal energy is one of the new renewable energies developed in Indonesia to date (Rame, Purwanto, & Sudarno, 2021). Figure 1 shows that until Q3-2021, the realization of increasing geothermal power plant capacity reaches 2% of the total of 11.2% of Indonesia's new renewable energy mix. The new renewable energy mix in 2019 in Indonesia reached 9.15%, increasing from 2.05% to 11.2% in Q3-2021 (Nagel, Dwiatmoko, & Windarta, 2022). Therefore, energy in Indonesia must immediately transition from fossil fuels to new renewable energy aimed at conserving natural resources (Ariawan, Windarta, & Dwiatmoko, 2022). The geothermal energy potential in Indonesia is the second largest in the world, with a potential of 23.76 gigawatts (GW), and the comparison of the realization of power plants with the existing geothermal energy potential is still below 10% (around 8.9%) (Mudassir, 2021).

According to the National Energy Council, one of the policies for optimizing the development of geothermal resources is to recommend using binary power plant technology for the use of medium-temperature geothermal (Siswanto, 2020). In addition, this policy encourages PLTP (Geothermal Power Plant) to use a combined cycle to maximize the utilization of existing geothermal energy.

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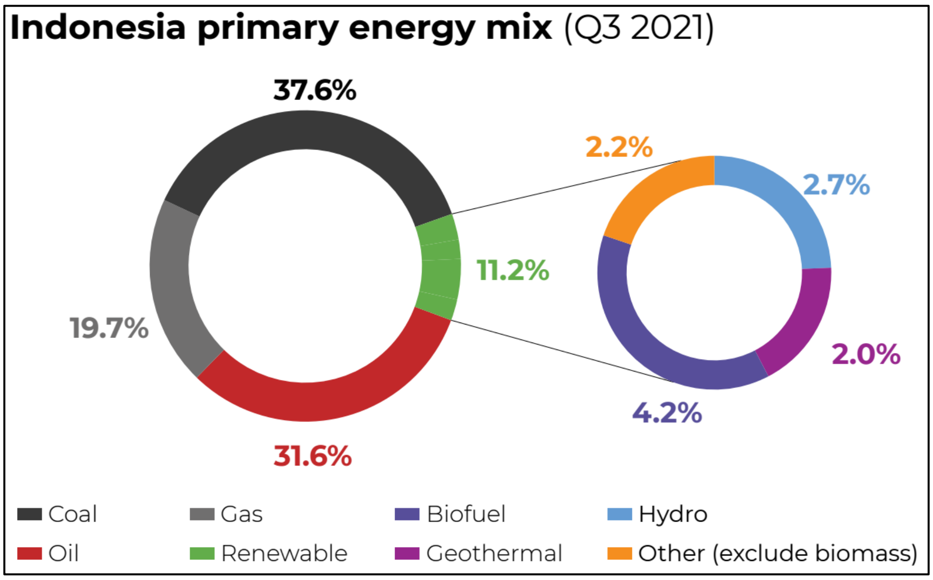

Figure 1. Indonesia Primary Energy Mix 2021 (IESR, 2021)

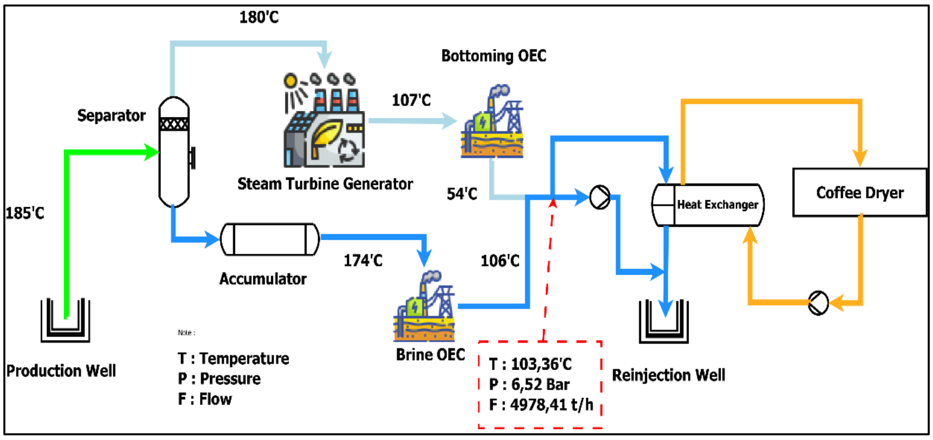

Figure 2. Research Concept Framework

Sarulla Geothermal Power Plant is a geothermal power plant located in North Tapanuli Regency, North Sumatra province. Sarulla is a consortium of several companies, including Medco Energi International Tbk., Itochu Corporation, Kyushu Electric Power Co., Inc., and Ormat (Wolf, 2015). Sarulla Operations Limited is Indonesia's first geothermal power plant that utilizes combined cycle technology. Ormat International developed this technology by combining single-flash technology with binary organic rankine cycle technology. The installed capacity of the generator is 330 MW (Rakhmadi & Sutiyono, 2015).

Geothermal fluids (geothermal production wells) produce steam (gas phase) and brine (liquid phase), which are then utilized indirectly by generating electricity, as shown in Figure 2. The steam rotates the turbine and produces 60 MW of energy at a pressure of around 10 bar and a temperature of about 180°C. The steam output from the turbine still has a temperature of 107°C, which flows to the Binary power plant Bottoming OEC (Ormat Energy Converter) through a heat exchanger and heats the second fluid, pentane, which has a low boiling point of around 30°C-400°C. The pentane, which has a low boiling point and has been heated, turns into a pressurized vapour, which is then used to turn a turbine and generate electricity with a total capacity of 7MW. The output steam from the generator is used towards the Bottoming OEC so that it is condensed into condensate at a temperature of around

54°C. The condensate at 54°C is directly injected back into the injection well into the earth after previously being combined with brine.

Brine (liquid phase) from production wells at a temperature of 174°C flows through a heat exchanger at Brine OEC. The principle used is almost the same as Bottoming OEC, namely heating pentane to turn it into a pressurized vapour and then turning a turbine and generating about 15MW of electricity. The brine output from the OEC Brine has a temperature of around 106°C. The remaining brine is combined with the condensate output from the Bottoming OEC and then injected back into the earth.

The residual fluid output from the generator in the form of condensate and brine, which has a temperature of around 103°C and is generally injected directly into the earth, can still be used for commercial business. According to (De Sousa & Domenici Roberto, 1998), the temperature of 90°C-95°C can still be maximized for community business development, as shown in Figure 3. Therefore, the authors want to maximize this potential for the development of further research.

In the early stages of its development, GPP Sarulla experienced resistance and obstacles from the local community. This was marked by the occurrence of rejection demonstrations in several locations requesting that the development of the Sarulla geothermal working area be stopped (Hutasoit, 2020). The community's refusal is based on the consideration that the existence of GPP will only disturb and damage the living environment and will not directly improve the local community's economy. Horizontal conflicts with local communities will always occur if the existence of GPP is not directly benefiting the community (Ahmad et al., 2021). The challenge of local community rejection can be reduced if the company is willing to empower local communities, especially in business development.

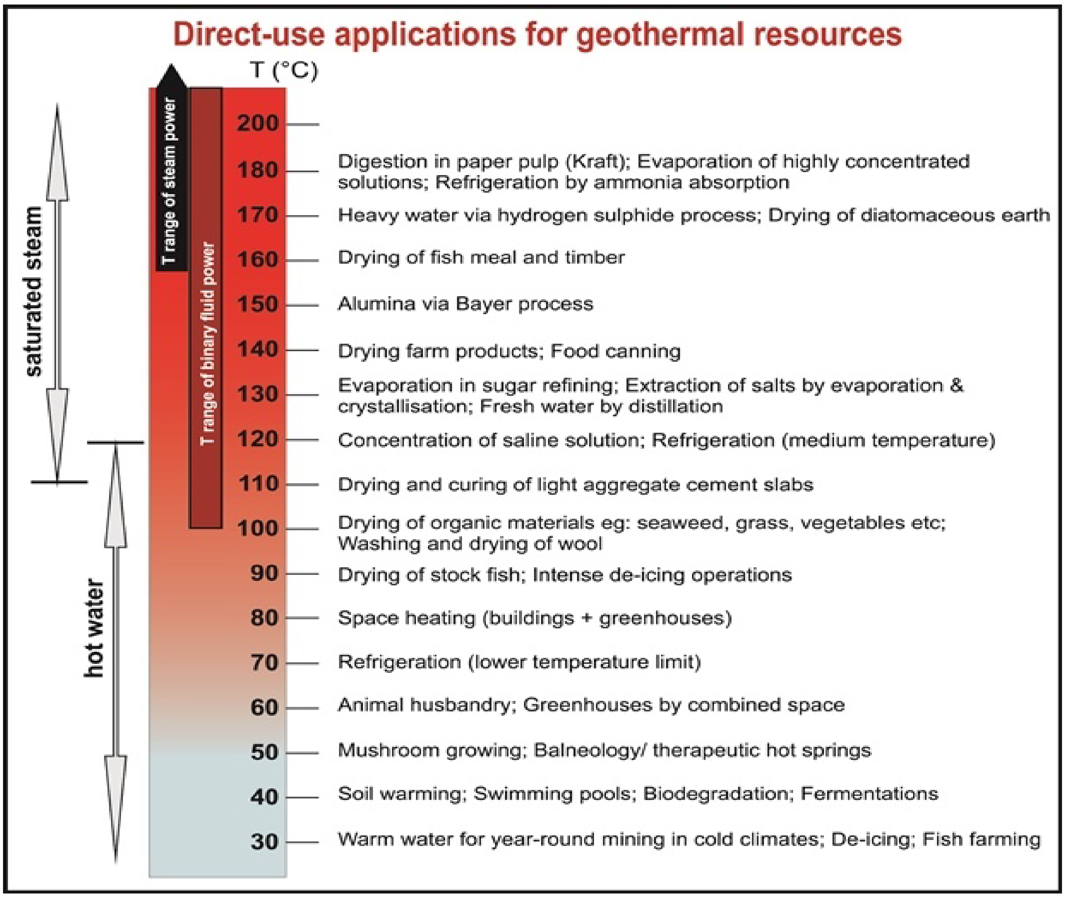

Figure 3. Lindal Diagram (Australian Academy of Science, 2015)

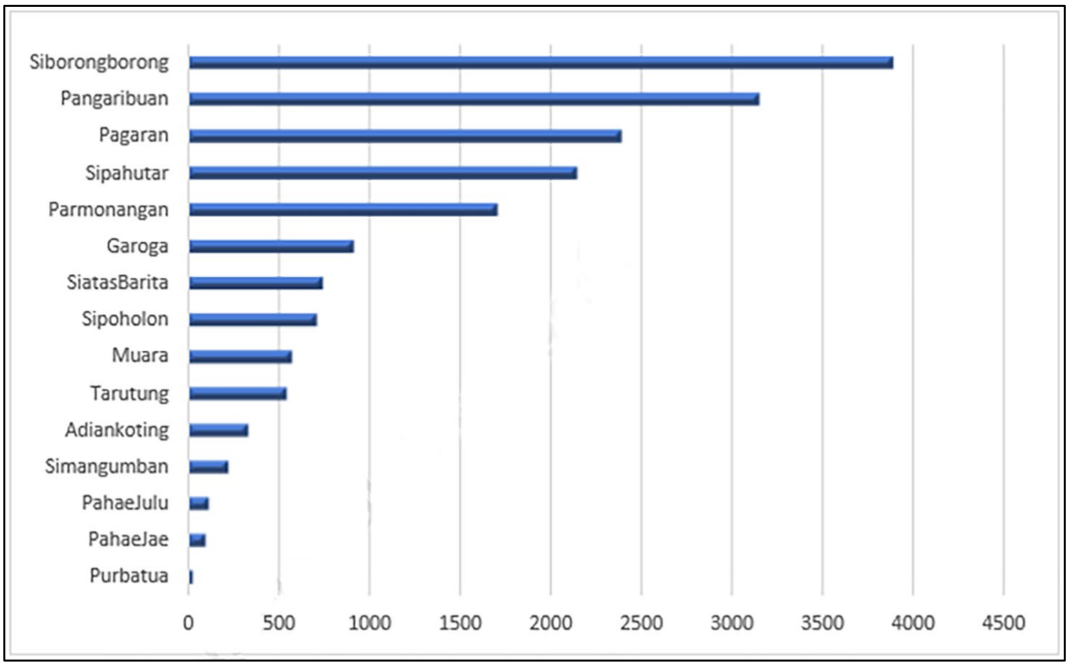

Figure 4. Coffee Production by Subdistrict in Tapanuli Utara Regency (ton) 2020 (BPS, 2021)

Figure 4 shows that coffee is the leading commodity in the North Tapanuli district. Including a coffee plant area coverage of 17,586 hectares, with the most significant plant area in the Siborongborong sub-district covering an area of 3,893.90 hectares (BPS, 2021).

This research is an answer to the local community's refusal to utilize the remaining geothermal fluid energy from the power plant in Sarulla to be used directly for drying coffee and direct use of geothermal energy in Mataloko to increase public acceptance (Ahmad et al., 2021). The fluid flowing into the reinjection well has a temperature of 103°C with a flow rate of 4978 t/h and a pressure of 6-14 bar. Therefore, the reinjected fluid energy can still be used directly for community business development in North Tapanuli, which is a coffee-producing area as a leading commodity (BPS, 2021), which still uses traditional coffee drying (drying in the open field) and is constrained by rain and cloudiness and can only be done during the day. This study analyzes the availability of energy and exergy for 24 hours a day so that coffee dryers can be carried out even though the weather is bad and at night.

2. METHODS

In this study, the authors used observational research methods (observation). As shown in Figure 5, this method collects data by recording the information during the study. The data processing method uses statistical testing means or the average value to get the average value for each variable with a total of 24 data points to describe the availability of the remaining fluid from the power plant for a full day for 24 hours. Secondary data from credible books and websites are needed to complete the research. Additional data comes from assumptions (like blower output in mass and pressure) to support calculations and simulations using DWSIM software. DWSIM is a chemical process simulation software that Daniel Wagner developed, and the software is open-source. The data is then processed to determine the energy and exergy values residual fluid can produce from the power plant.

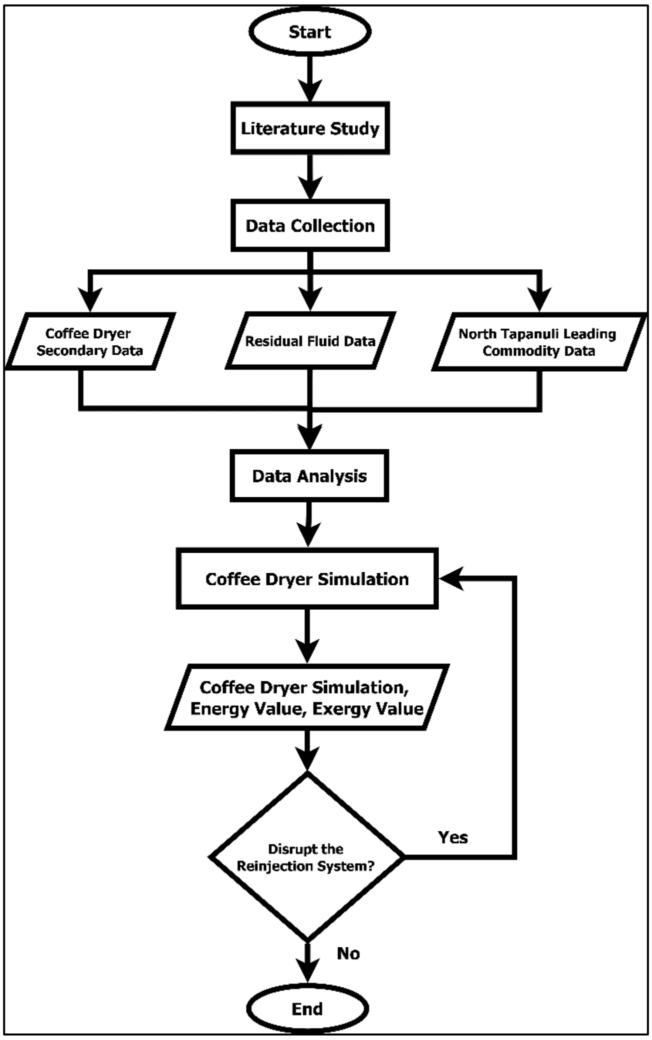

Figure 5. Research Flowchart

3. RESULT AND DISCUSSION

3.1. Energy and Exergy

Analysis of the performance of a system requires the concept of energy balance following the first law of thermodynamics. The first law of thermodynamics states that energy can neither be created nor destroyed. This law is often known as the law of conservation of energy. A system that changes from an initial state to a state of equilibrium or a final state can absorb and release energy into the system's surroundings. When no more changes exist in the system, a state of equilibrium is created. A state of equilibrium occurs when there is no change in the unbalanced force acting on it. The energy contained in the initial and final states makes it very difficult to determine the results of the total content, so measurements are carried out by measuring the difference between the energy of the initial state and energy in the final state and the energy exchanged between the system and its environment (Abdulaziz, 2020).

According to Rajput (Rajput, 2012), the energy balance that occurs in the heat exchanger can be determined with the assumption that no heat is lost to the environment and changes in potential and kinetic energy can be neglected. Then the equation for

$$Q_{hot} = m_h C_{ph}(T_h, in - T_h, out) \tag{1}$$

$$\boldsymbol{Q_{cold} = m_c C_{pc}(T_c, out - T_h, in)} \tag{2}$$

The heat energy released by Qhot as a heat medium has the same value as the heat energy absorbed by Qcold as a heat conducting medium, so the equation is given.

$$\boldsymbol{Q = m_h C_{ph}(T_h, in - T_h, out) = m_c C_{pc}(T_c, out - T_c, in)} \tag{3}$$

Where m is the flow rate value in kg/s, and Cp is the specific heat value at constant pressure in J/kg. K, T is the fluid temperature in Kelvin or Celsius, while the symbols h and c refer to the hot fluid h (hot) and cold fluid c (cold). The heat transfer in the heat exchanger media varies throughout the heat exchanger area. This value can be determined by LMTD (logarithmic mean temperature difference). The LMTD for a heat exchanger with a counter-flow arrangement is determined by the equation:

$$\boldsymbol{\theta_m = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)}} \tag{4}$$

Where $\boldsymbol{\theta_m}$ is the LMTD in °C units, $\boldsymbol{\theta_1}$ is the difference between $\boldsymbol{T_{c,in}}$, which is the temperature of the hot fluid input and $\boldsymbol{T_{c,out}}$, which is the temperature of the cold fluid output in °C units, $\boldsymbol{\theta_2}$ is the difference between $\boldsymbol{T_{c,out}}$, which is the temperature of the hot fluid output, while $\boldsymbol{T_{c,in}}$, is the temperature of the cold fluid entered in units of °C.

The LMTD value, according to Kreith (Kreith, Manglik, & Bohn, 2011), can be used to determine the overall heat transfer coefficient in the heat exchanger with the equation:

$$\boldsymbol{q = UA\overline{\Delta T}} \tag{5}$$

Where q is the heat energy in W units, and U is the overall heat transfer coefficient in the heat exchanger in units of $\boldsymbol{W/m2.K}$, A is the heat transfer surface area in units of m^2, and $\boldsymbol{\overline{\Delta T}}$ is the LMTD ($\boldsymbol{\theta_m}$). From equation 5, we get the following equation :

$$\boldsymbol{A = \frac{q}{(U)(\overline{\Delta T})}} \tag{6}$$

Equation 6 can determine the heat exchanger's total heat transfer surface area in m^2.

Calculation of exergy, according to (Moran, Shapiro, Boettner, & Bailey, 2014), is carried out by evaluating the change in the total exergy flow from the input flow to the output flow in the heat exchanger by ignoring kinetic energy and potential energy. The determination of the exergy change can be calculated using the following equation :

$$\boldsymbol{m(e_2 - e_1) = m(h_2 - h_1) + T_o(s_2 - s_1)} \quad (7)$$

Where $\boldsymbol{m(e_2 - e_1)}$ is the exergy of the hot fluid flow in units of W, $\boldsymbol{m(h_2 - h_1)}$ is the difference between the enthalpy value of the hot fluid output and the enthalpy of the incoming hot fluid multiplied by m as mass, $\boldsymbol{T_o(s_2 - s_1)}$ is the difference between the entropy of the hot fluid output and the entropy of the hot fluid entering it multiplied by T_o as the ambient reference temperature in °C. The symbol number 2 refers to the hot fluid output, and the number 1 refers to the hot fluid input. Equation 7 has the same principle in determining the exergy value for cold fluids using the equation :

$$\boldsymbol{m(e_4 - e_3) = m(h_4 - h_3) + T_o(s_4 - s_3)} \quad (8)$$

Number 4 refers to the cold fluid output, and number 3 refers to the cold fluid input. The exergy destruction value in the heat exchanger can be determined by the equation:

$$\boldsymbol{E_d = m(e_2 - e_1) + m(e_4 - e_3)} \quad (9)$$

Where $\boldsymbol{E_d}$ is the exergy destruction value in W units, while $\boldsymbol{m(e_2 - e_1)}$ is the exergy of the hot fluid flow in W units, and $\boldsymbol{m(e_4 - e_3)}$ is the exergy of the cold fluid flow in W units.

Figure 6 shows the reinjection brine data, taken from the brine output and condensate used to generate electricity, which flows to the reinjection well. Brine output from Brine OEC and condensate from vapour condensation at Bottoming OEC from 2 units, namely Unit 1 and Unit 2 of the Sarulla NIL Power Plant, are then combined and flowed to the reinjection well. Table 1 shows the data taken from pressure, temperature, and brine flow rate data. They were taken from the central control room of the power plant on October 31, 2021, when there were 9 production wells available out of a total of 11 production wells. Two production wells are under periodic inspection and maintenance.

Table 1. Brine Reinjection Data

Parameter	Temperature (°C)	Pressure (Barg)	Flow Rate (Kg/h)
Highest Value	106,360	6,83	5.009.644
Lowest Value	101,578	6,29	4.944.730
Average Value	103,360	6,52	4.978.410

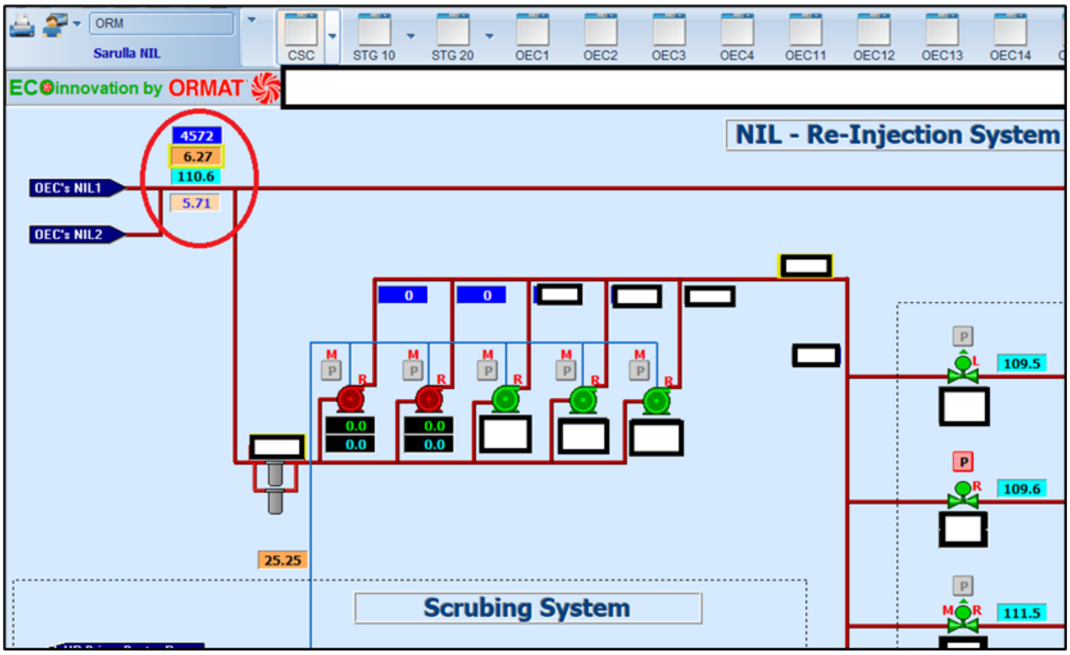

Figure 6. Research Data Collection Point

Table 2. Air Temperature Data as an Input

Data source	Range	Information
BMKG (BMKG, 2022)	Minimum : 13,0 °C – 16,5 °C Maximum: No information	The temperature in the North Tapanuli area
Weatherspark (Weather Spark, 2022)	Minimum: 18°C – 19 °C Maximum: 27 °C – 29 °C	Sarulla's temperature

Table 3. Data on Coffee Drying Temperature

Data source	Temperature
Balai Pengkajian Teknologi Pertanian (BPTP) Lampung (BPTP Lampung, 2018)	40°C - 60 °C
Rancang Bangun dan Pengujian Alat Pengering Biji Kopi Tenaga Listrik Dengan Pemanfaatan Energi Surya (Gultom & T., 2019)	45 °C – 50 °C
Perancangan Mesin Pengering Biji Kopi Semi Otomatis Kapasitas 25 kg (Fauzi & Widiantoro, 2021)	50 °C – 55 °C
Dispersion Coefficient of Coffee Berries in Vibrated Bed Dryer (Finzer, Sfredo, Sousa, & Limaverde, 2007)	40 °C – 50 °C
Karakteristik Pengerringan Biji Kopi Berdasarkan Variasi Kecepatan Aliran Udara Pada Solar Dryer (Yani & Fajrin, 2013a)	50 °C – 55 °C

The input air data to increase temperature is taken from the ambient air around the power plant. Table 2 shows that the data comes from 2 references, BMKG and Weatherspark. The data is in the form of a minimum and maximum temperatures achieved in the power plant area. The maximum air temperature represents the hot air temperature during the day, while the minimum air temperature represents the cold air temperature at night.

Coffee drying is carried out at a specific temperature to maintain the quality of the coffee beans so that there is no damage to the coffee beans. Suitable drying air temperatures for Arabica and Robusta coffee beans were varied in multiples of 10°C to 40°C, 50°C, and 60°C. Table 3 shows the temperature required for drying coffee.

3.2. Result of Energy Calculation

The overall energy balance of the heat exchanger can be assumed to be that the heat exchanger is well insulated, and the heat energy loss to the surroundings is insignificant and can therefore be neglected. The energy balance can be expressed by equation 3, where m is the mass flow value in kg/s. C_p is the specific heat at constant pressure in J/kg.K. T is the average fluid temperature in K, both the inlet (in) and outlet (out) temperatures. The symbols h and c refer to hot and cold media as heat conductors.

Table 4 shows the brine data parameters from the power plant used as input brine in the heat exchanger. The pressure value (p), the flow rate value (m), and the temperature value (t) are the average values of the overall data. The flow rate value is converted into units of kg/s, while for the specific heat, it is converted into units of J/kg.K. The specific heat value refers to the temperature of 375 K = 101,85°C, representing the specific heat value of the brine temperature of 103,360°C.

Table 5 shows the input air data parameters. The assumption of an air mass of 10 t/h is converted into units of kg/s and an air pressure of 2 bar gauge to describe the blower used to provide air intake to the dryer. The specific heat value of air (Cp) refers to the specific heat value of air at a temperature of 300 K = 26,85°C to represent the ambient air temperature of 25°C. The output air temperature refers to the temperature required for drying coffee beans.

The output temperature of the brine determined the heat transfer value from brine to air, which is already known by equation 1. The calorific value obtained from the brine mass product, the specific brine heat, and the difference between the input brine temperature and the output brine temperature value produce a value of heat energy from brine. The heat transfer value between brine and air with a mass of 10 t/h to reach a temperature of 50°C from an initial temperature of 25°C is 69.792 J/s or 70 kW.

Table 6 above shows the value of the energy required to raise the ambient air temperature for each temperature variation from the initial temperature to the expected final temperature for a dryer using equation 3 and equation 1.

Table 4. Parameters of Brine Data

Parameter	Pressure (p)	Flow Rate (m)	Temperature (t)	Specific Heat (Cp)
Value	6,52	4.978.410	103,360	4,220
Units	Barg	Kg/h	Celcius	kJ/kg.K
Conversion		1.382,892		4.220
Conversion Unit		Kg/s		J/kg.K
Information	Brine as input	Brine as input	Brine as input	375 K = 101,85 °C
Source	Primary data	Primary data	Primary data	Secondary Data

Table 5. Air Data Parameters

Parameter	Pressure (p)	Flow Rate (m)	Temperature Input (Tin)	Temperature Output (Tout)	Specific Heat (Cp)
Value	2	10.000	25	50	1,005
Units	Barg	Kg/h	Celcius	Celcius	kJ/kg.K
Conversion		2,78			1.005
Conversion Unit		Kg/s			J/kg.K
Information	Air Input	Air Input	Air Input	Air Output	300 K = 26,85 °C
Source	Assumption	Assumption	Secondary Data	Secondary Data	Secondary Data

Figure 7 shows that a large amount of energy is needed to raise the temperature from 15°C to 60°C at 125,62 kW, while the smallest amount of energy is needed to raise the temperature from 30°C to 40°C at 27,92 kW. This shows that the ambient air temperature in Table 2 dramatically affects the energy required to raise the air temperature for the coffee dryer.

The relatively high daytime temperatures require little energy to raise the temperature for drying. However, at night, when the ambient air temperature tends to be relatively low, it takes much energy to raise the temperature for drying purposes.

According to Kreith (Kreith et al., 2011), the heat transfer distribution in the heat exchanger between the heat medium and the heat conducting medium generally is not constant but varies along the heat transfer area. Therefore, the temperature value at a particular part of the heat exchanger varies where heat is transferred between the hot medium and the heat conducting medium. Logarithmic Mean Temperature Difference is the temperature distribution value that can occur in a heat exchanger.

A better heat transfer value in counter-flow requires a smaller heat transfer surface with the same heat transfer value (Rajput, 2012).

The LMTD value of the temperature distribution in Figure 8 for a counter-flow heat exchanger can be determined using equation 4, where θ_m is 65°C.

The heat exchanger analysis has the most uncertain and important part, namely determining the overall heat transfer coefficient. The coefficient is the total thermal resistance to heat transfer between two fluids (Bergman & Lavine, 2017).

Table 6. Brine Temperature 103,36 °C Heat Transfer Energy

Ambient Air Temperature (°C)	Brine Heat Transfer Energy to Air (kW)		
	T1 = 40 °C	T2 = 50 °C	T3 = 60 °C
15	69,79	97,71	125,62
20	55,83	83,75	111,67
25	41,88	69,79	97,71
30	27,92	55,83	83,75

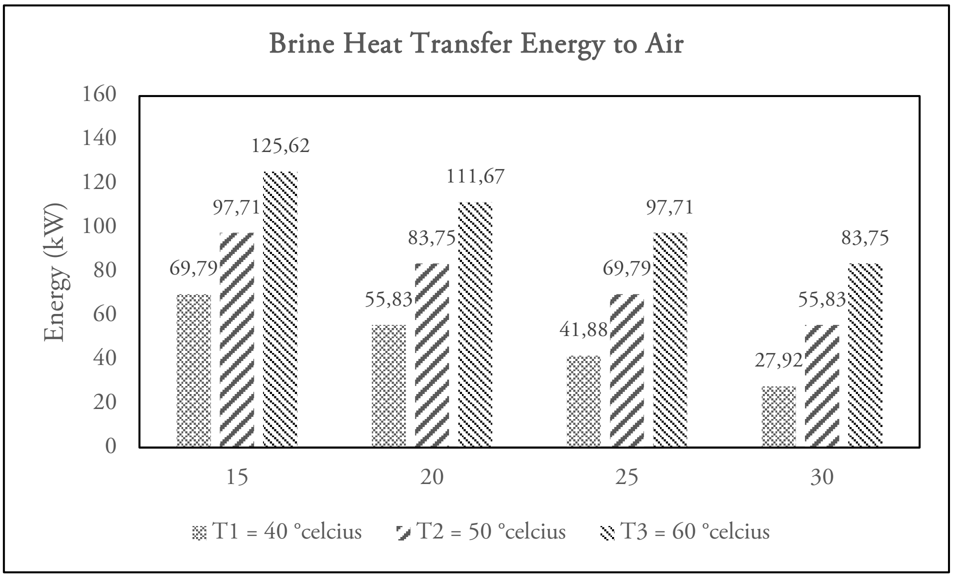

Figure 7. Energy Graph of Brine to Air Heat Transfer

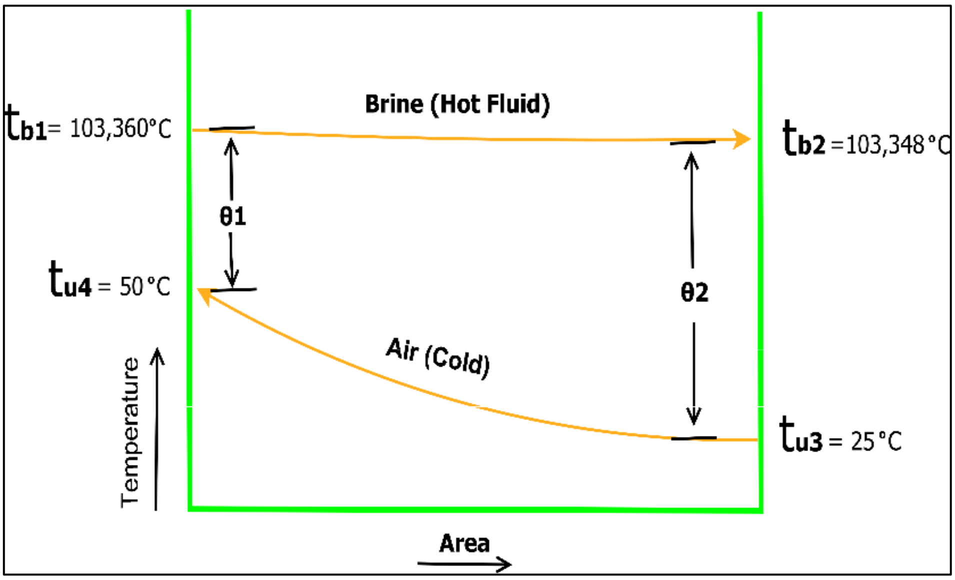

Figure 8. Research Data Collection Point

From equation 5, assuming the overall heat transfer coefficient in the heat exchanger is 1070 W/m^2.K, the overall heat transfer coefficient of the steam condenser (water in tubes) is 1000-6000 W/m^2.K (Bergman & Lavine, 2017), then the heat transfer surface area can be determined by equation 6 with a surface area of A = 1 m^2. This surface area is the basis of the design of the heat exchanger in the coffee dryer.

3.3. Exergy Calculation Results

The exergy value that occurs in the heat exchanger is determined by the type of heat medium and the heat conducting medium through which the heat exchanger passes. According to (Moran et al., 2014), the calculation of exergy in this study can be determined with the following assumptions of the technical modelling:

- There is no significant transfer of heat energy from the system to the environment.
- Changes in kinetic energy and potential energy at the inlet and outlet flows of the heat exchanger are negligible.
- Air is modelled as an ideal gas.
- Environmental temperature and pressure reference based on ambient air conditions

The information in Table 7 can be used to determine the exergy value of heat transfer from brine as a hot medium using equation 7. Regarding the enthalpy of brine output and the enthalpy of brine input, the environmental reference temperature in T_o and the entropy values of the output brine and the input brine, the exergy value of the brine is $m(e_2 - e_1)$ = -70 kW. The minus value of exergy indicates that the energy released by brine in the heat exchanger is -70 kW.

From the data in Table 8, it can be determined the exergy value of air as a heat conducting medium using equation 8 regarding the enthalpy value of the output air and the enthalpy of the input air, the environmental reference temperature in T_o and the entropy value of the output air, the intake air, and the ideal gas value. The exergy value of air is obtained from the air of $m(e_4 - e_3)$ = 3 kW. The positive exergy value indicates that the energy received by the air in the heat exchanger to raise the temperature is 3 kW.

From the brine exergy value and the air exergy value, it can be determined how much of the exergy destruction value occurs in the heat exchanger by using equation 9 with the obtained exergy destruction of E_d = -67 kW. From the calculation results, the exergy destruction value that occurs in the heat exchanger is -67 kW, which means much energy that is not maximally used in the heat exchanger.

Table 7. Enthalpy and Entropy Values of Brine

Parameter	Brine			
	Value	Units	Source	Information
Mass (m)	1.382,892	Kg/s	Primary data	Brine Input
Enthalpy-1 (hf1)	433,239	kJ/kg	Table A-2 (T1 = 103,360 °C)	Interpolation
Enthalpy-2 (hf2)	433,189	kJ/kg	Table A-2 (T2 = 103,348 °C)	Interpolation
Entropy-1 (sf1)	1,34440	kJ/kg.K	Table A-2 (T1 = 103,360 °C)	Interpolation
Entropy-2 (sf2)	1,34426	kJ/kg.K	Table A-2 (T2 = 103,348 °C)	Interpolation
Ambient temperature (To)	298,15	Kelvin	25 °C	Environmental Reference : Air

Table 8. Enthalpy and Entropy Values of Air

Parameter	Brine			
	Value	Units	Source	Information
Mass (m)	2,78	Kg/s	Primary data	Air Input
Enthalpy-3 (h3)	298,333	kJ/kg	Table A-22 (T3 = 298,15 K)	Interpolation
Enthalpy-4 (h4)	323,4526	kJ/kg	Table A-22 (T4 = 323,15 K)	Interpolation
Entropy-3 (so3)	1,695785	kJ/kg.K	Table A-22 (T3 = 298,15 K)	Interpolation
Entropy-4 (so4)	1,776722	kJ/kg.K	Table A-22 (T4 = 323,15 K)	Interpolation
Ambient temperature (To)	298,15	Kelvin	25 °C	Environmental Reference: Air Constant
Air molecular weight (M)	28,97	Kg/mol	Ideal Gas	
Pressure-3 (P3)	2	Barg		Assumption
Pressure-4 (P4)	2	Barg		Assumption

3.4. DWSIM Simulation Results

The heat exchanger can be simulated using DWSIM software to determine the temperature value and the energy that can be generated from the heat transfer that occurs from both the heat medium and the heat conductor, as shown in Figure 9. Furthermore, the results of this simulation can be compared with the results of manual calculations to find out that there is no significant difference between the simulation results and manual calculations.

Table 9 shows the heat exchanger and brine and air simulation results. The simulation results of a counter-flow heat exchanger for an air temperature of 25 °C increased to 50 °C showed a heat load of 69.6179 kW with an LMTD of 65 °C.

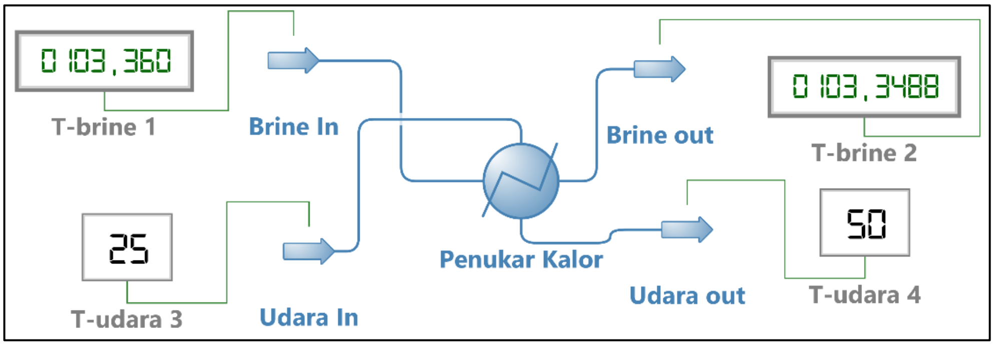

Figure 9. Simulation of a DWSIM Heat Exchanger

Table 9. (A) Heat Exchanger, (B) Brine and Air Simulation Results

Heat Exchanger (A)		
Object	Heat Exchanger	
Global Heat Transfer Coefficient (U)	1070,11	W/[m^2.K]
Heat Exchanger Area (A)	1	m2
Heat Load	69,6179	kW
Cold Fluid Outlet Temperature	50	C
Hot Fluid Temperature	103,349	C
Logarithmic Mean Temperature Difference LMTD	65,0565	C
Thermal Efficiency	31,8163	%

Brine and Air (B)					
Object	Brine In	Brine Out	Air in	Air out	
Temperature	103,36	103,349	25	50	C
Pressure	6,52	6,52	2	2	Bar
Mass Flow	4,97841E+06	4,97841E+06	10000	10000	Kg/h
Molecular Weight (Vapour)	0	0	28,96	28,96	Kg/mol
Heat Capacity (Liquid 1)	4,22135	4,22134	0	0	Kj/[kg.K]
Phases	Liquid Only	Liquid Only	Vapour Only	Vapour Only	
Ideal Gas Heat Capacity Cp (Vapour)	1,89235	1,01848	1,00142	1,00365	Kj/kg

Table 10. Heat Transfer Energy Temperature 103,36°C Simulation Results

Ambient Air Temperature (°C)	Brine Heat Transfer Energy to Air (kW)		
	T1 = 40 °C	T2 = 50 °C	T3 = 60 °C
15	69,56	97,42	125,32
20	55,66	83,52	111,42
25	41,75	69,62	97,51
30	27,84	55,71	83,60

Table 10 above shows the simulation results of heat transfer energy from brine to air. The resulting energy value is almost the same as the manual calculations using equation 1. Therefore, the standard deviation between manual calculations and simulations is set at a minimum value of 0.056569 and a maximum value of 0.212132.

3.5. Silica Scale Formation Rate

The performance of the heat exchanger depends on the heat transfer between the two media that exchange heat energy. Silica is a substance found in geothermal fluids. Silica can form a scale on the heat exchanger, which causes a decrease in performance due to the thickening of the heat exchanger material, according to research that has been carried out (Sarulla Operation Ltd., 2021) to determine the rate of silica formation from reinjection fluid at the Sarulla power plant. The results showed a decrease in the OEC brine output temperature caused by increased electricity production to maximize the available brine. The OEC brine output temperature is 105°C - 110°C from the initial temperature of 129°C. The results showed that to get a low silica deposition rate of < 1 mm/year, the temperature must be >104°C and pH < 4. The heat exchanger in this study used hot media in the form of heat from brine with a temperature of 103ºC, so the rate of silica formation is >1mm/year. The heat exchanger can still be used with the provision of periodic maintenance of the heat exchanger in the event of a decrease in performance of the heat exchanger. The temperature of the inlet brine can also return to high if the two wells in the maintenance phase are returned to the system.

3.6. Coffee Drying Advantages and Disadvantages

Traditional coffee drying (drying in the open field) carried out by farmers generally has weaknesses. Rain and cloudiness are the main obstacles to traditional drying and can only be done during the day (Yani & Fajrin, 2013b). Meanwhile, drying using residual geothermal fluid through a heat exchanger can dry at night and is available 24 hours a day without being disturbed by the weather. However, drying coffee using a heat exchanger is very expensive. Nevertheless, this can be done away with the help of corporate social responsibility.

3.7. Geothermal CO_2 Emissions

Energy sourced from geothermal has the lowest CO_2 emissions compared to other energy sources such as natural gas, fuel oil, and coal. For example, in Figure 10, geothermal energy produces the smallest emissions among other energy sources in generating electricity and heating power plants compared to coal, which produces the highest emissions in generating electricity and heating power plants. Coffee dryers can also use gas fuel from liquefied petroleum gas (Djafar, Piarah, Djafar, & Riadi, 2018) but still produce high CO_2 emissions compared to geothermal energy. So geothermal energy is perfect for the environment because it produces the most negligible CO_2 emissions.

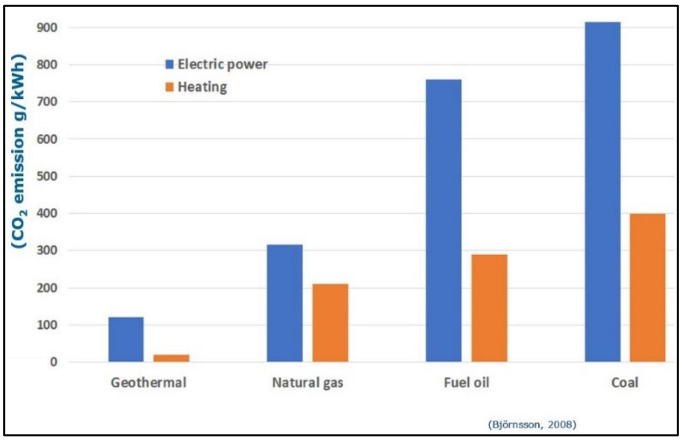

Figure 10. CO_2 Emissions from Electric and Heating Power Plants, From Different Energy Sources (Gissurarson & Arason, 2018)

4. CONCLUSION

Energy from brine reinjection of 70 kW is sufficient to raise the air temperature from 25°C to 50°C with a mass of 10 tons/hour required for drying coffee beans. The exergy destruction value during heat transfer in the heat exchanger at an air temperature of 25°C to 50°C is 67kW. Drying coffee beans does not interfere with the power plant's reinjection system because fluid temperature changes do not change significantly. The rate of silica formation in the reinjection pipe is highly dependent on the temperature and pH of the power plant brine reinjection, so periodic maintenance is required to prevent the heat exchanger from deteriorating. The simulation results have the same results as the manual calculations. The standard deviation between manual calculations and simulations is set at a minimum value of 0.056569 and a maximum value of 0.212132.

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