Proceedings of the 6th ITB International Graduate School Conference
Multidisciplinary Collaboration for Sustainable Energy: Science,
Technology, Policy, and Society

Enhancing Geothermal Energy Utilization Through Binary Power Plant and Absorption Chiller Technology: Songa Wayaua Case

Aria Pratama Putra[1,2,*] & Jooned Hendrarsakti[1]

[1] Geothermal Engineering Master's Program - Faculty of Mining and Petroleum Engineering (FTTM), Institut Teknologi Bandung (ITB), Jl. Ganesha 10, Bandung 40132, Indonesia
[2] PT PLN (Persero), Jalan Trunojoyo Blok M-1 No. 135, Jakarta, Indonesia

*Email: aria.putra@pln.co.id

Abstract The Songa Wayaua Geothermal Power Plant (PLTP) is planned for development with a 2x5 MW capacity using single-flash technology. The residual energy contained in the brine from the separator outlet can be further utilized before being reinjected. Referencing a study by PT. PLN (Persero), the brine stream from the single-flash plant, with a mass flow rate of 29.33 kg/s and a temperature of 164.9°C, will be directed into a cascaded system. This system comprises an Organic Rankine Cycle (ORC) for additional power generation and a Lithium Bromide-Water (LiBr-H_2O) absorption chiller for cooling purposes. This approach is particularly promising given the Songa Wayaua geothermal field's coastal proximity, making it suitable for future applications like fish refrigeration systems. The proposed design is projected to generate an additional 312.17 kW of power $w_{gener\dot{a}tor}$ using Pentafluoropropane (R-245fa) as the working fluid. The ORC system's outlet temperature is maintained at a maximum of 125°C, allowing it to be subsequently used as the heat source for the absorption chiller. This chiller is estimated to produce a cooling capacity $\dot{Q}_e$ of 835.91 kW, with a Coefficient of Performance (COP) of 0.76 and an effectiveness (e) of 0.78. The results of this study indicate that the proposed system can significantly increase the overall energy efficiency and expand the application scope of the geothermal potential. This allows for the direct integration of geothermal energy with the local fishery industry, fostering a direct, mutually beneficial relationship between PT. PLN (Persero) and the community surrounding Songa Wayaua.

Keywords: *Geothermal Energy, Absorption Chiller System, Organic Rankine Cycle, Songa Wayaua*

1 Introduction

Indonesia possesses significant geothermal potential, reaching 23.592 MW[1], the majority of which is currently utilized for Geothermal Power Plants. One such field with geothermal potential is the Songa Wayua geothermal field, which is managed by PT. PLN (Persero). Located on Bacan Island, South Halmahera Regency, North Maluku Province which can be seen in **Figure *1***. This field is distinguished from other geothermal sites by its unique coastal location and the presence of a well-established local fishing industry. Based on a feasibility study by PT. PLN (Persero), this field is slated for development with a 2x5 MW geothermal power plant utilizing single-flash technology [2]. A key challenge with this system is the production of high-temperature waste brine from the separator, which contains residual energy that can be further exploited. This energy can be harnessed through a cascaded system comprising a binary cycle bottoming unit for additional power generation and a Lithium Bromide-Water (LiBr-H_2O) absorption chiller for cooling applications.

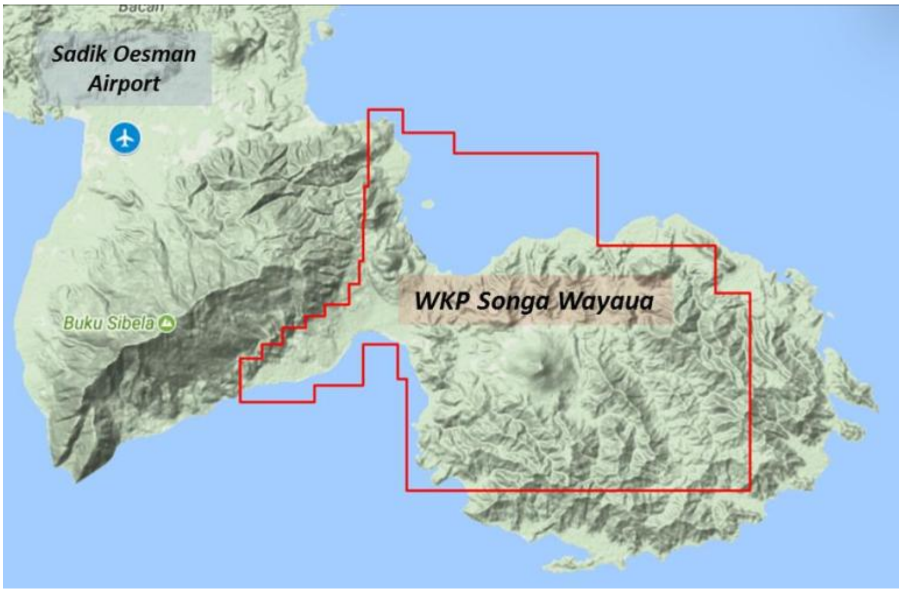

Figure 1. Location of Songa Wayaua Geothermal Working Area in South Halmahera Regency, Bacan Island, North Maluku Province

A binary cycle power plant is a system capable of generating electricity from waste or residual heat sources. The two primary types of binary cycles are the Organic Rankine Cycle (ORC) and the Kalina Cycle. Unlike the conventional Rankine cycle which uses water as the working fluid, the ORC employs an organic fluid [3]. These organic fluids typically have a lower boiling point and a higher vapor pressure than water at equivalent thermodynamic states. The Kalina Cycle, in contrast, utilizes a mixture of ammonia and water as its working fluid, with the compositional percentage varying based on specific operating conditions [4].

In addition to binary power plants, various industrial technologies exist to utilize waste heat and significantly improve energy efficiency. One such technology is the Lithium Bromide-Water (LiBr-H_2O) absorption chiller system. A LiBr-H_2O system primarily consists of an evaporator, absorber, generator, condenser, solution pump, and expansion valve. In this system, water serves as the refrigerant and Lithium Bromide (LiBr) acts as the absorbent. As these systems are commonly used for air conditioning, the evaporator temperature is maintained above 0°C to prevent the water-refrigerant from freezing [5]. For the Songa Wayua field, this cooling technology presents a valuable opportunity for the direct use of geothermal energy, specifically for developing a fish cold storage facility to support the local fishing industry.

Therefore, this research aims to design and optimize an integrated cogeneration system (power and cooling) that combines ORC and absorption chiller technologies. The primary objectives are to maximize the overall energy efficiency of the geothermal resource utilization and to create added economic value for the community surrounding the Songa Wayua geothermal field.

2 Formulation of Analysis Modelling

2.1 System Description

The system proposed in this study is a cogeneration system integrating an Organic Rankine Cycle (ORC) and an Absorption Chiller, designed to utilize waste heat from the separator of planned Single Flash Geothermal Power Plant with capacity 1x5 MW as illustrated in **Figure** *2*. For the cooling system, the LiBr−H2O pair is chosen for its high affinity and thermal stability, while the single-stage setup offers simplicity, cost efficiency, and meets the necessary temperature lift for the process [6].

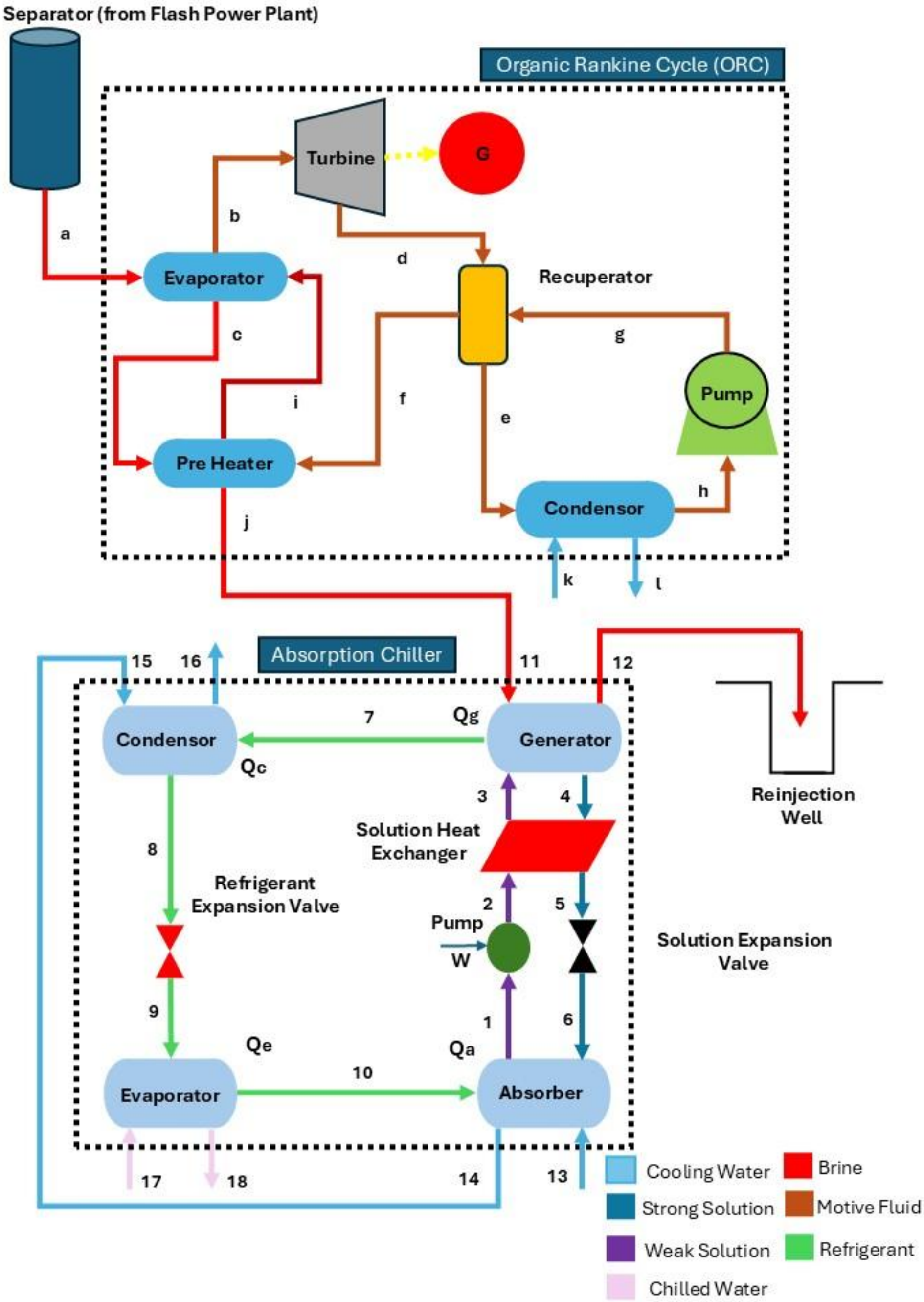

Figure 2. Schematic Diagram of Cascading Organic Rankine Cycle and Absorption Chiller

Brine from the separator is first directed to the ORC system, where its heat vaporizes an organic working fluid to drive a turbine and generate additional electricity. After releasing some heat in the ORC (state point j) , the brine then serves as a heat source (state point 11) for the generator of a single-stage LiBr-H_2O absorption chiller. This chiller produces a cooling effect (Qe) in its evaporator, suitable for various applications like space cooling or industrial processes. Following passage through the absorption chiller's generator (state point 12), the now cooler brine is reinjected. This integrated system aims to enhance overall geothermal energy utilization efficiency by simultaneously generating additional electricity and providing cooling, thereby optimizing the Songa Wayaua field's resources.

2.2 Absorption Chiller Single Stage

The Single Stage Absorption Chiller system used in this configuration utilizes heat from the ORC brine outlet to produce a cooling effect. This study This study uses thermodynamic analysis [7]. The single-stage LiBr-H_2O absorption chiller system utilizes heat from the ORC brine outlet to produce a cooling effect. Its schematic diagram is shown in Figure 2. The system operates within two pressure zones: high pressure in the generator and condenser, and low pressure in the absorber and evaporator. The LiBr-H_2O solution acts as the absorbent, with water serving as the refrigerant. Operation below 0°C must be avoided to prevent refrigerant freezing in the evaporator.

To simplify the thermodynamic analysis, the following fundamental assumptions are applied: steady flow throughout the system; negligible pressure losses and pump work input; isenthalpic expansion valve operation; and saturated conditions at the solution outlets from the generator and absorber, as well as at the refrigerant outlet from the condenser. Mass and energy balances for each component are formulated based on variables including $\dot{Q}$ (heat rate), $\dot{m}$ (mass flow rate), h (enthalpy), T (temperature), UA (overall heat transfer coefficient), C_P (Spesific Heat Transfer Coefficient) and x (LiBr-H_2O concentration).

- Generator

$$\dot{m}_3 = \dot{m}_4 + \dot{m}_7 \tag{1}$$

$$\dot{Q}_g + \dot{m}_3 h_3 = \dot{m}_4 h_4 + \dot{m}_7 h_7 \tag{2}$$

$$\dot{Q}_g = m_{11} \dot{C}_p (T_{11} - T_{12}) \tag{3}$$

$$\dot{Q}_g = (UA)_g \frac{(T_{11} - T_4) - (T_{12} - T_7)}{\ln\left(\frac{T_{11} - T_4}{T_{12} - T_7}\right)} \tag{4}$$

- Evaporator

$$\dot{m}_9 = \dot{m}_{10} \tag{5}$$

$$\dot{Q}_e + \dot{m}_9 h_9 = \dot{m}_{10} h_{10} \tag{6}$$

$$\dot{Q}_e = \dot{m}_{17} C_P (T_{17} - T_{18}) \tag{7}$$

$$\dot{Q}_e = (UA)_e \frac{(T_{17} - T_{10}) - (T_{18} - T_9)}{\ln\left(\frac{T_{17} - T_{10}}{T_{18} - T_9}\right)} \tag{8}$$

- Condensor

$$\dot{m}_7 = \dot{m}_8 \tag{9}$$

$$\dot{Q}_c + \dot{m}_8 h_8 = \dot{m}_7 h_7 \tag{10}$$

$$\dot{Q}_c = m_{15} \dot{C}_p (T_{16} - T_{15}) \tag{11}$$

$$\dot{Q}_c = (UA)_C \frac{(T_8 - T_{15}) - (T_7 - T_{16})}{\ln\left(\frac{T_8 - T_{15}}{T_7 - T_{16}}\right)} \tag{12}$$

- Refrigerant Expansion Valve

$$\dot{m}_8 = \dot{m}_9 \tag{13}$$

$$\dot{m}_8 h_8 = \dot{m}_9 h_9 \tag{14}$$

- Absorber

$$\dot{m}_1 = \dot{m}_6 + \dot{m}_{10} \tag{15}$$

$$\dot{m}_1 x_1 = \dot{m}_6 x_6 \tag{16}$$

$$\dot{m}_1 (1 - x_1) = \dot{m}_6 (1 - x_6) + \dot{m}_{10} \tag{17}$$

$$\dot{Q}_a + \dot{m}_1 h_1 = \dot{m}_6 h_6 + \dot{m}_{10} h_{10} \tag{18}$$

$$\dot{Q}_a = \ \dot{m}_{13} C_p (T_{14} - T_{13}) \tag{19}$$

$$\dot{Q}_a = (UA)_a \frac{(T_6 - T_{14}) - (T_1 - T_{13})}{\ln\left(\frac{T_6 - T_{14}}{T_1 - T_{13}}\right)} \tag{20}$$

- Solution Heat Exchanger

$$\dot{m}_2 = \dot{m}_3 \tag{21}$$

$$\dot{m}_4 = \dot{m}_5 \tag{22}$$

$$\dot{m}_2 h_2 + \dot{m}_4 h_4 = \dot{m}_3 h_3 + \dot{m}_5 h_5 \tag{23}$$

- Solution Expansion Valve

$$\dot{m}_5 = \dot{m}_6 \tag{24}$$

$$\dot{m}_5 h_5 = \dot{m}_6 h_6 \tag{25}$$

For the purpose of this analysis, the LiBr concentration (x) is held constant for several state points, namely $x_1 = x_2 = x_3$ and $x_4 = x_5 = x_6$. The performance of the solution heat exchanger is quantified by its effectiveness, which is defined as the quotient of the actual heat transfer rate over the maximum attainable heat transfer rate, expressed as :

- Efficiency

$$\varepsilon = \frac{T_4 - T_5}{T_4 - T_2} \tag{26}$$

The coefficient of performance (COP) of the absorption chiller for cooling purposes can be written as:

- Coefficient of Performance (COP)

$$COP = \frac{\dot{Q}_e}{\dot{Q}_g} \tag{27}$$

2.3 Enthalpy LiBr-H_2O

The calculation of thermodynamic properties, particularly enthalpy, of the Lithium Bromide-Water (LiBr-H_2O) solution for analyzing the performance of the Absorption Chiller System [8]. Enthalpy at various points in the cycle is used in energy balance equations to determine heat transfer and work. In this study, the enthalpy (h) of the LiBr-H_2O solution in kJ/kg is calculated using a polynomial equation which is a function of LiBr concentration (X in %) with range 40<X<70% and temperature (t in °C) with range 15<t<165 °C.

$$h = \sum_0^4 A_n X^n + t \sum_0^4 B_n X^n + t^2 \sum_0^4 C_n X^n \tag{28}$$

Table 1. The coefficients involved in Equation 28

	0	1	2	3	4
A	-2024,33	163,309	-4,88161	6,302948 e-2	-2,913705
B	18,2829	-1,1691757	3,248041 e-2	-4,034184 e-4	1,8520569 e-6
C	-3,7008214 e-2	2,8877666 e-3	-8,1313015 e-5	9,9116628 e-7	-4,4441207 e-9

The use of this equation allows for the accurate determination of enthalpy values at various operating conditions encountered in the absorption cooling cycle.

2.4 Organic Rankine Cyle (ORC) Binary Power Plant

The binary power plant with an Organic Rankine Cycle (ORC) is designed to extract thermal energy from geothermal fluid (brine) at lower temperatures, which would be inefficiently utilized by conventional flash steam power plants. In this system, heat from the brine between state points a and j is used to heat and vaporize an organic working fluid that has a lower boiling point than water.

This study simulates the system by applying mass and energy balance equations to its primary components: the evaporator, preheater, turbine, generator, recuperator, condenser, and pump [9]. A control volume approach is used for component analysis, employing equations that model mass and energy conservation. The mass and energy balances for each component are formulated based on variables such as $\dot{Q}$ (heat rate), $\dot{m}$ (mass flow rate), W (work rate), h (enthalpy), S (Enthropy), T (temperature), UA (overall heat transfer coefficient), and x (LiBr concentration), ε (Efficiency).

The subsequent analysis involves the calculation of heat transfer from the brine within the evaporator and preheater. The heat balance calculation for the brine fluid is used to estimate the total heat transfer from the brine to the Organic Rankine Cycle system $\dot{Q}_{in\_total}$.

A. Calculating from Brine Fluid

- Evaporator

$$\dot{Q}_{evapbrine} = \dot{m}_a (h_a - h_c) \tag{29}$$

- Preheater

$$\dot{m}_a = \dot{m}_c \tag{30}$$

$$\dot{Q}_{preheaterbrine} = \dot{m}_c\left(h_c - h_j\right) \quad (31)$$

$$\dot{Q}_{preheaterbrine} = (UA)_{preheater}\frac{(T_C - T_i) - (T_j - T_f)}{\ln(\frac{(T_C - T_i)}{(T_j - T_f)}} \quad (32)$$

- Total Energy

$$\dot{Q}_{in\_total} = \dot{Q}_{preheaterbrine} + \dot{Q}_{evapbrine} \quad (33)$$

$$\dot{Q}_{in\_total} = \dot{m}_a\left(h_a - h_j\right) \quad (34)$$

Following the calculation of heat transfer from the brine fluid, a heat balance analysis is conducted for the working fluid. This subsequent calculation allows for the analysis of the power that can be generated by the turbine. Consequently, the system's efficiency can be determined by comparing the net power output ($\dot{W}_{turbine}$) and pump energy output ($\dot{W}_{pump}$) to the total heat transferred from the brine ($\dot{Q}_{in\_total}$).

B. Calculating from Working Fluid

- Evaporator

$$\dot{m}_i = \dot{m}_b \quad (35)$$

$$\dot{m}_b = \frac{(h_b - h_i)}{\dot{Q}_{evap}} \quad (36)$$

$$\dot{Q}_{evapwf} = \dot{m}_b(h_b - h_i) \quad (37)$$

$$\dot{Q}_{evapbrine} = \dot{Q}_{evapwf} \quad (38)$$

- Preheater

$$\dot{m}_f = \dot{m}_i \quad (39)$$

$$\dot{Q}_{preheaterwf} = \dot{m}_i(h_i - h_f) \quad (40)$$

$$\dot{Q}_{preheaterbrine} = \dot{Q}_{preheaterwf} \quad (41)$$

- Turbine

$$S_b = S_d \quad (42)$$

$$\dot{m}_b = \dot{m}_d \quad (43)$$

$$\dot{W}_{turbıne} = \dot{m}_b \varepsilon_{turbine}(h_b - h_{d_s}) \tag{44}$$

$$h_d = h_b - (\varepsilon_{turbine}(h_b - h_{d_s})) \tag{45}$$

- Recuperator

$$\dot{m}_d = \dot{m}_e = \dot{m}_g = \dot{m}_f \tag{46}$$

$$\dot{Q}_{recup} = \dot{m}_d(h_e - h_d) = m_g(\dot{h}_f - h_g) \tag{47}$$

- Condensor

$$\dot{m}_e = \dot{m}_h \tag{48}$$

$$\dot{Q}_{cond} = \dot{m}_e(h_h \dot{-} h_e) \tag{49}$$

$$\dot{Q}_{cond} = (UA)_{cond} \frac{(T_e - T_l) - (T_h - T_k)}{\ln(\frac{(T_e - T_l)}{(T_h - T_k)}} \tag{50}$$

- Pump

$$S_h = S_g \tag{51}$$

$$\dot{m}_h = \dot{m}_g \tag{52}$$

$$\dot{W}_{pump} = \frac{\dot{m}_h(h_h - h_{g_s})}{\varepsilon_{pump}} \tag{53}$$

$$h_g = \left(\frac{h_{g_s} - h_h}{\varepsilon_{pump}}\right) + h_h \tag{54}$$

A heat balance analysis of the cooling tower is necessary for the condensation process, which converts the working fluid from a vapor to a liquid phase before it re-enters the preheater and evaporator.

C. Calculating from Cooling Fluid

- Condensor

$$\dot{m}_k = \dot{m}_l \tag{55}$$

$$\dot{Q}_{cond} = \dot{m}_k C_p(T_l - T_k) \tag{56}$$

The performance of the Binary Power Plant is quantified by its effectiveness, which is defined as the quotient of the actual heat transfer rate from brine and energy output form Turbine. he corresponding equations are as follows:

3 Result and Discussion

Mass and energy balance calculations for the ORC and absorption chiller system, utilizing Coolprop [10], require input data and assumptions from **Table 2**. Model parameters were sourced from engineering and commercial data, including brine data from a single-flash power plant feasibility study's separator outlet and absorption system specifications from commercially available products. Key simulation inputs include external fluid flow rate, operating temperature, and turbine and pump isentropic efficiencies. Subsequent calculations yielded critical output parameters such as system loop flow rate, thermodynamic state points, heat transfer magnitude, Coefficient of Performance (COP), and overall system efficiency.

Table 2. Input Parameters

Input Parameter	**Value**	**Input Parameter**	**Value**
Organic Rankine Cycle (ORC)			
$\dot{m}_a$	29,33 kg/s	$\varepsilon_{turbine}$	0,9
P_a	7 bar	$\varepsilon_{generator}$	0,95
T_a	164,9 °C	ε_{pump}	0,8
T_{PP}	5 °C	T_k	33 °C
		T_l	34 °C
Absorption Chiller Lithium Bromide (LiBr-H$_2$O)			
$\dot{m}_3$	4 kg/s	T_{13}	32 °C
$\dot{m}_{11}$	13,2179 kg/s	T_{16}	40 °C
$\dot{m}_{13}$	62,7373 kg/s	T_{17}	12 °C
$\dot{m}_{15}$	62,7373 kg/s	T_{18}	7 °C
$\dot{m}_{17}$	39,9955 kg/s	T_{11}	125 °C
P_{high}	7,406 kPa	T_{12}	105 °C
P_{low}	0,676 kPa		

3.1 Organic Rankine Cycle (ORC) Result

This system is designed using Pentafluoropropane (R-245fa) as the working fluid and utilizes the waste heat from the separator outlet brine of a planned Single Flash type Geothermal Power Plant.

Table 3. ORC Operating Conditions at State Points

State Point	From	To	Mass Flow (kg/s)	Temperature (°C)	Pressure (Bar)	Enthalphy (kJ/Kg)
a	Separator	Evaporator	29,33	164,9	7	696,8
b	Evaporator	Turbine	35,95	134,5	25,6	489,0
c	Evaporator	Preheater	29,33	139,5	7	587,5
d	Turbine	Recuperator	35,95	104,93	13,63	479,8
e	Recuperator	Condensor	35,95	103,39	13,63	477,8
f	Recuperator	Preheater	35,95	105,92	25,6	349,1
g	Pump	Recuperator	35,95	103,4	25,6	347,1
h	Condensor	Pump	35,95	103,4	25,6	345,8
i	Preheater	Evaporator	35,95	134,5	25,6	399,8
j	Preheater	Outlet to Reinjection Well	29,33	125,0	7	525,4
k	Inlet from Cooling Tower	Condensor	1136,15	33,0	1	138,4
l	Condensor	Outlet to Cooling Tower	1136,15	34,0	1	142,5

$\dot{Q}_{in\_total}$	5027,29 kW
$\dot{w}_{turbine}$	328,60 kW
$\dot{w}_{generator}$	312,17 kW
$\dot{w}_{pump}$	49,71 kW

Based on the calculation results in **Table** *3*, the generator power that can be generated is 312.17 kW. Based on this energy output addition from Binary Power Plant, the generatable power can increase the efficiency of electricity production at the Songa Wayaua field under the same number of wells. Output temperature of Pre Heater are 125 °C in which part of its fluid will be used for the absorption chiller.

3.2 Absorption Chiller Single Stage

The simulated single-effect system can be seen in **Table 4**, which details the operational conditions and thermodynamic properties at each state point. The table includes data for the external fluid circuits integrated with the chiller.

Table 4. Absorption Chiller Operating Conditions at State Points

State Point	From	To	Mass Flow (kg/s)	Temperature (°C)	Pressure (Bar)	Enthalphy (kJ/Kg)	Fraction (%)
1	Absorber	Pump	4,00	33,0	0,00676	83,58	56,149
2	Pump	Solution Heat Exchanger	4,00	33,00	0,07406	83,58	56,149
3	Solution Heat Exchanger	Generator	4,00	61,59	0,07406	141,83	56,149
4	Generator	Solution Heat Exchanger	3,64	89,41	0,07406	198,61	61,644
5	Solution Heat Exchanger	Solution Expansion Valve	3,64	45,17	0,07406	134,66	61,644
6	Solution Expansion Valve	Absorber	3,64	45,17	0,00676	134,66	61,644
7	Generator	Condenser	0,36	85,73	0,07406	2660,65	0
8	Condensor	Refrigerant Expansion Valve	0,36	38	0,07406	159,17	0
9	Refrigerant Expansion Valve	Evaporator	0,36	1,402	0,00676	159,17	0
10	Evaporator	Absorber	0,36	1,402	0,00676	2503,47	0
11	Pre Heater (ORC Cycle)	Generator	13,218	125			0
12	Generator	Injection Well	13,218	105			0
13	Cooling Tower	Absorber	62,74	32			0
14	Absorber	Condenser	62,74	36			0
15	Absorber	Condenser	62,74	36			0
16	Condenser	Cooling Tower	62,74	39,4			0
17	Chilled Water In	Evaporator	39,99	12,0			0
18	Evaporator	Chilled Water Out	39,99	7,0			0

$\dot{Q}_g$	1105,01 kW
$\dot{Q}_c$	891,95 kW
$\dot{Q}_a$	1048,97 kW
$\dot{Q}_e$	835,906 kW

COP	0,76
ε	0,78

Based on this system, it is shown that the energy that can be generated reaches 835.906 kW. In addition, the COP (Coefficient of Performance) of the system here is 0.76. Based on previous studies on utilizing geothermal energy for cooling system [11], the COP (Coefficient of Performance) can be increased by adjusting the cooling setpoint temperature at the evaporator outlet (T_{18}). A higher generator input temperature (T_{11}) also results in an increased COP. However, using a higher input temperature from a binary power plant could, in turn, reduce the power plant's energy output.

4 Conclusion

This study presents a mathematical modeling of an Organic Rankine Cycle (ORC) Binary Power Plant system and a LiBr-H2O Absorption Chiller, utilizing the waste heat present in the separator outlet brine of a single-flash technology power plant. The calculation and modeling results indicate that by utilizing brine from the power plant in the Songa Wayaua geothermal working area, it is possible to generate $\dot{W}_{generator}$ = 312.17 kW and $\dot{Q}_e$ = 835.906 kW. Based on this study, it was also found that there is a COP (Coefficient of Performance) = 0.76 It can be seen that this cascaded system can increase the utilization of the Songa Wayaua field. This research needs to be further developed, especially regarding the energy utilization of the Absorption Chiller for Cold Fish Storage, in accordance with the region's future potential.

References

[1] PT. Perusahaan Listrik Negara, "Rencana Usaha Penyediaan Tenaga Listrik 2025 - 2034," *PT. Perusah. List. Negara*, pp. 2019–2028, 2019.

[2] PT. Perusahaan Listrik Negara, "PRE-FEASIBILITY STUDY OF SONGA-WAYAUA GEOTHERMAL WORKING AREA FINANCED BY PLN," no. April, 2020.

[3] F. . Ahangar, "Feasibility Study of Developing a Binary Power Plant," *Geotherm. Train. Program.*, no. 6, p. 24, 2012.

[4] G. E. E. Dela Cruz and M. C. E. Manuel, "A Literature Review of the Kalina Cycle and Trends," *IOP Conf. Ser. Earth Environ. Sci.*, vol. 1046, no. 1, 2022, doi: 10.1088/1755-1315/1046/1/012011.

[5] S. Alabd Mohamed and M. Nawab Karimi, "Simulation of Lithium Bromide-Water (LiBr-H2O) Vapor Absorption System (VAS) powered by Solar Flat Plate Collector (SFPC)," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 691, no. 1, 2019, doi: 10.1088/1757-899X/691/1/012031.

[6] S. Khosravi, N. B. Desai, F. Haglind, and A. Arabkoohsar, "Techno-economic analysis of partial evaporation and sub-critical organic Rankine cycle systems integrated with an absorption heat transformer," *Energy*,

vol. 326, p. 136366, 2025, doi: 10.1016/j.energy.2025.136366.

[7] M. El Haj Assad, M. Tawalbeh, T. Salameh, and A. Al-Othman, "Thermodynamic analysis of lithium bromide absorption chiller driven by geothermal energy," *5th Int. Conf. Renew. Energy Gener. Appl. ICREGA 2018*, vol. 2018-Janua, pp. 76–81, 2018, doi: 10.1109/ICREGA.2018.8337607.

[8] A. Standard, "ASHRAE Handbook 2009 Fundamentals (SI Edition)," *Ashrae Stand.*, pp. 24–25, 2009.

[9] B. T. Prasetyo *et al.*, "The integrative use of binary cycle technology to improve thermal efficiency and efficiency in geothermal power plants: A case study of Ulumbu geothermal power plant in Indonesia," *Energy Convers. Manag.*, vol. 321, no. June, p. 119033, 2024, doi: 10.1016/j.enconman.2024.119033.

[10] I. H. Bell, J. Wronski, S. Quoilin, and V. Lemort, "Pure and pseudo-pure fluid thermophysical property evaluation and the open-source thermophysical property library coolprop," *Ind. Eng. Chem. Res.*, vol. 53, no. 6, pp. 2498–2508, 2014, doi: 10.1021/ie4033999.

[11] C. Maragna, A. Altamirano, B. Tréméac, F. Fabre, L. Rouzic, and P. Barcellini, "Design and optimization of a geothermal absorption cooling system in a tropical climate," *Appl. Energy*, vol. 364, no. March, 2024, doi: 10.1016/j.apenergy.2024.123102.