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Study on Power Plant Configurations to Optimize Mass Flow Consumption with Respect to Silica Scaling for Dieng Unit 2, Indonesia

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ABSTRACT

Dieng geothermal field located in Central Java, Indonesia, operated by PT Geo Dipa Energi (Persero) with existing power plant Unit 1 commissioned in 2002 of 60 MW and a complementary small-scale plant commissioned in 2021 of 10 MW. As a continuation of development, project Dieng Unit 2 has started with a generation capacity of 55 MW net. To develop this new unit, one of the main challenges in Dieng, silica scaling shall be considered due to the high concentration of silica in Dieng. Studies and testing to find the recommended power plant design parameter for Unit 2 have been done several times by the consulting company and internally. The testing itself is known as the pilot plant which was conducted single flash, combined cycle with binary or Organic Rankine Cycle (ORC), and double flash. Findings from the pilot plant testing to date indicate significant potential difficulties in operating a binary combined cycle plant at Dieng due to heat exchanger scaling from high concentrations of heavy metal sulfides in the fluid. Since the lower pressure of double flash remains uncertain, the assumed Silica Scaling Index (SSI) >1.2 as the manageable limit is taken and subject to test in the future. The calculation was conducted using Python and Ms. Excel and verified with EES, the correlation between mass flow from wells and separator pressure including the Specific Steam Consumption (SSC) are found. The power plant configuration used is single flash condensing type and double flash condensing type with enthalpy assumption 1300 kJ/kg and 1600 kJ/kg. Based on this study, the required mass flow for single flash separator pressure ranging from 12.5 bara to 25.7 bara will be 260 kg/s to 405 kg/s with pressure directly proportional to the mass flow required from the wells. While for double flash calculation, the overall required mass flow is ranging from 235 to 360 kg/s and the separator pressure correlation with mass flow is directly proportional. For Specific Steam Consumption (SSC), the pressure inversely proportional with the SSC which means the higher the pressure, the lower SSC. Recommendation on the power plant use is double flash using high pressure separator 25 bara and low pressure 12.5 bara. Second recommendation is single flash using 25 bara. This recommendation, especially the double flash need to be check in the pilot plant to gather more comprehensive information about silica scaling index and silica scaling rates.

1. INTRODUCTION

Located in Central Java, Wonosobo, and Banjarnegara Regency, the Dieng geothermal power plant Unit 1 operates since 2002 for 60 MW and a complementary 10 MW small scale unit has been operating since 2021. Furthermore, in 2019, project Dieng unit 2 has started to develop another 55 MW known as Unit 2. Dieng area located near to community, an agricultural area, and tourism area which makes this field challenging to be studied. Other than the surroundings, the resource of Dieng also challenging due to the minerals content such as high concentration of silica. Scaling of silica in surface facilities and reinjection wells are challenges that have been experienced since the project was put into operation almost 20 years ago. Based on the operating experience to date, further study has been conducted to ensure the technology selection of Unit 2 is suitable for exploitation at least for 30 years of operations. The previous study which consists of the feasibility study, silica mitigation study, and brine management study, concluded that the experimental study in the field needed to answer several questions to design and operate the Dieng unit 2. This experimental study in the field is later known as pilot plant testing.



Figure 1: Dieng geothermal power plant location

In Dieng geothermal field there are 4 reservoirs named Sileri, Candradimuka, Sikidang, and Pakuwaja. Based on the available data, the reservoir temperature in Dieng is 280-330 ºC. Initial pressure-temperature data shows that the reservoir temperature has reached more than 330 ºC, particularly in Sileri Area, the production area which is used for Unit 1. While separated brine and power plant

condensate is reinjected to both the Sileri and Sikidang areas. The Dieng geothermal reservoir is water dominated with a dryness approximation of 30% with an area calculated around 6.2 km^2 (Geo Dipa Energi, 2019).

Unit 1 was initially operated using hot brine injection, with separated brine pumped from separator directly to reinjection wells for disposal. The brine handling system included an acid dosing system for pH control. Scaling rates in surface piping and injection wells were unmanageable, even when pH modification was in operation. The Dieng Unit 1 brine system was subsequently converted to cold injection, requiring the use of a series of storage ponds where brine is held and conditioned, to enable silica to deposit in the ponds, reducing the scaling load on surface facilities and wells. The injection of brine in 2002 using a hot brine injection system, with acid injection for pH modification. This strategy changed in 2005 with a cold brine injection system with acid injection after separator and brine aged and cooled in holding ponds before injection. The brine conditioning ponds represent an environmental risk through potential brine spills, particularly during the wet season, and the ongoing requirement to recover and dispose of silica scale deposited in the ponds. Consequently, the development plan for Unit 2 anticipates the adoption of hot brine disposal. Unit 1 uses wellpad separators with separation pressures in the range of 10-11 bara. Geothermal fluids discharged from the wells are typically near-neutral pH and high salinity with total dissolved solids at the production separators ranging from 20,000 to 35,000 ppm. Based on the historical data, well HCE-7C produced the highest levels of silica in flashed brine with a geothermometer quartz temperature is 330oC. On the other hand, well HCE-30 has produced the second-highest levels of silica in flashed brine with a geothermometer quartz temperature is 318ºC. In these two wells, the average silica concentration is 800 ppm in the reservoir. It has been established that the silica saturation temperature of Sileri fluids ranges from 195oC to 220oC, which is higher than the flash temperature in the Unit 1 separators. Therefore, separated brine typically has a Silica Saturation Index (SSI) greater than 1.0. One of the pictures of silica scaling in pipeline brine is shown in Figure 1.

Financial closing was achieved in part of feasibility study in 2019, and in 2020 the loan agreement with Asian Development Bank (ADB) was signed, therefore the document of the project will also be available on the ADB website. Furthermore, the development plan for Dieng Unit 2 in feasibility study considering the silica scaling challenge and a binary combined cycle power plant as the preferred technology, recommended the 10 wells to be drilled to ensure the fluids available to generate 55 MW and return fluid to the geothermal reservoir. The start-up production with the total amount of fluids required by the combined cycle is still uncertain depending on average enthalpy, with average enthalpy amount 1300-1600 kJ/kg, the maximum total fluids to deliver is 1049 t/h or 6 dedicated production wells. And for the single flash, the required mass flow is 1667 t/h or 7 dedicated wells production required (ELC, 2019). The development map which consists of the well pad, preliminary piping routes, and power plant location shown in Figure 1, needs to be updated after the findings of pilot plant testing and FEED.

The objective of this paper is to give the approach of designing the power plant with consideration of the silica scaling after having the result of the testing is one of the representatives well. The other objectives are findings of the pilot plant result, calculating the silica scaling based on thermodynamic condition, and also proposing the recommended power plant configurations based on the findings and calculations. Several parameters of the power plant will be varied to investigate the optimization of mass flow consumption. The assumption used is based on studies before this paper including pilot plant testing results. In parallel with further pilot plant scaling experiments in Dieng, the study result in this paper needs to be confirmed. For the current stage, the effort shall be focused to find the preliminary design parameter of Dieng Unit 2. Preliminary testing using the pilot plant indicates significant potential difficulties in operating a binary combined cycle plant at Dieng due to heat exchanger scaling from high concentrations of heavy metal sulphides in the fluid. At this point, a steam flash cycle offers better operational reliability and is currently the preferred development option. Hence, this paper is limited to the configuration design only for single flash and double flash condensing types.

2. POWER PLANT DESIGN

In the feasibility study, the preferred technology is the combined cycle which consists of a single flash, backpressure steam turbine, ORC bottoming turbine, and ORC brine. The minimum brine temperature required to control heavy metal sulphides influence deposits means that the improved thermal efficiency of a binary plant is unlikely to be achievable. Hence, the power plant configuration in this study is single flash with condensing turbine and double flash with condensing turbine. The thermodynamic equations of the power plants were modeled using Python programming language especially the Spider with properties of the fluid database called CoolProp (Coolprop, 2021). Optimization of the power plant configuration is conducted to find the mass flow consumption and steam consumption for the net power output of each power cycle. These steps are drawn in the flowchart of study in Figure 3 below. The turbine inlet pressure needs to be considered carefully in Dieng. The wells supplying Unit 1 are considered to represent the chemistry that we are likely to get for Unit 2 wells. The Silica Saturation Temperature (SST) for the bulk of the Unit 1 wells, if the well HCE-31 excluded, has a very low SST indicating there is probably a condensate feed or other dilution into the well ranges from 195ºC to 220ºC. This temperature represents separation pressures of about 19-24 bara. If the bulk of the wells for Unit 2 are at the lower end of this temperature range, then it would be preferable to set the power plant inlet pressure lower so that the mass flow and flash ratio for these wells could be maximized. If a well exhibits higher SST, then the separation pressure for that well could be set higher so SSI<1.0 and the steam pressure reduces using a steam line pressure control valve after that separator. The selection of the lowest possible turbine inlet pressure potentially increases the steam production from the field by up to 11%.

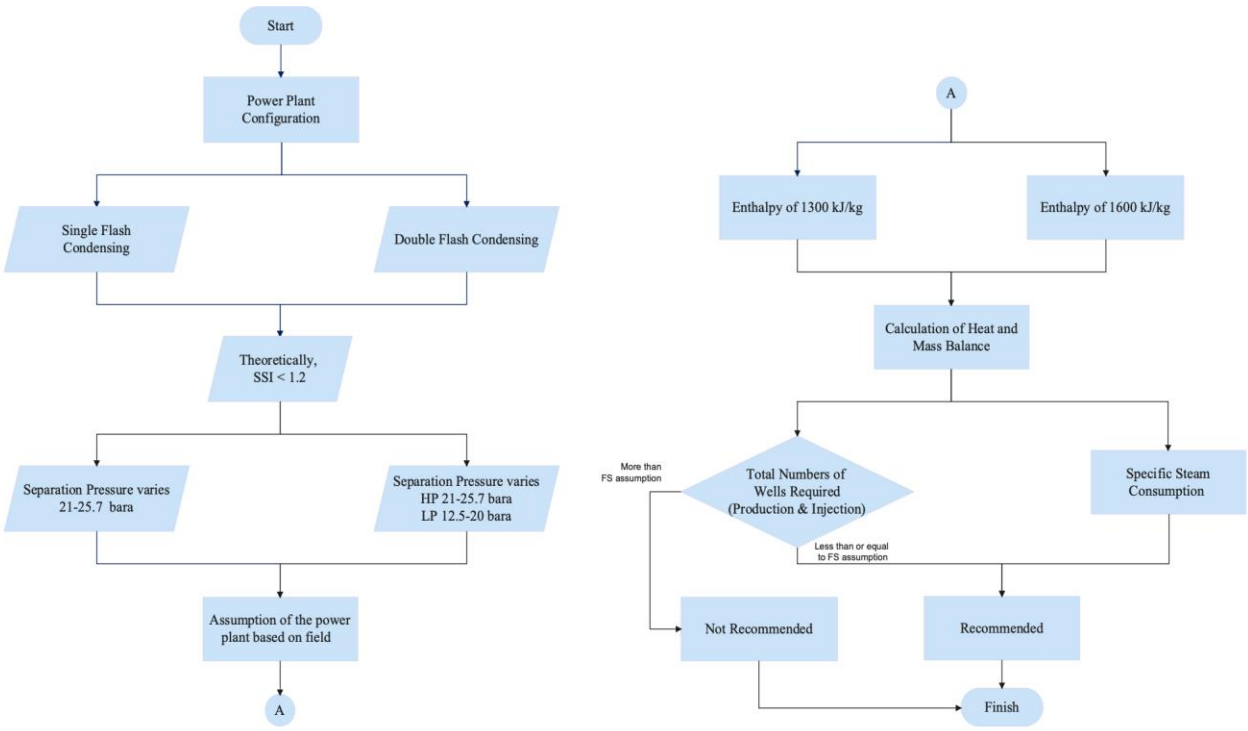


Figure 2: Flowchart of study

The wide enthalpy range is one of the resource risks identified and needs to be mitigated by the optimization of equipment sizing during detailed engineering to avoid over/under specification and the designation of power plant need to be flexible to accommodate enthalpy input. The calculation is limited on the NCG (Non-Condensable Gas) and need further research to absorb the calculation of NCG using 3%. Therefore, using the parameter in table 1, The pilot plant result shows that the pressure of the HP Separator is recommended to be 21.2 to 25.7 bara. Findings in the pilot plant will guide another additional testing parameter. To give alternative engineering design, the engineering division can calculate the optimization of condensing units of the power plant. In Table 1, the design parameter and assumption are given as a basis of calculation. The SSI which is shown in Figure 2 concluded that the lower pressure shall be more than 11.57 bara with acceptable SSI > 1.2, then by assuming approximately 1 bara as pressure drop from the separator to the turbine, can be concluded the lowest separator pressure is 12.5 bara.

Table 1: Assumption of power plant

Assumption	Value	Basis of Assumption
Power (net)	55 MW	Energy Sales Contract (ESC)
Reservoir Temperature	300-330ºC	Based on Feasibility Study Report
Enthalpy of fluids at the wellhead	1300-2100 kJ/kg	Based on Feasibility Study Report
Single Flash separation pressure	12.5-25.7 bara	Constraint SSI ≤ 1.2
Double Flash separation pressure	High Pressure 21.2-25.7 bara Low Pressure 12.5-20 bara	Constraint SSI ≤ 1.2
The efficiency of the dry turbine	85%	wet expansion in single and double flash units, the turbine efficiency is corrected by using the Baumann rule
Efficiency of pumps	70%	
Pressure loss of turbine valve	1 bara	
Temperature of condenser	45ºC	
Pressure of condenser	0.08 bara	
Temperature wet bulb	20ºC	Average wet bulb temperature measured at field
Temperature CT approach	8ºC	
Auxiliary power (Parasitic Load)	4 MW	

2.1 Single Flash Condensing System

At least, the major component of the surface facilities of the single flash condensing system power plant consists of a wellhead, separator, mist eliminator, steam turbine, generator, condenser, gas removal system, cooling tower, and pumps. The simplified schematic diagram for the single flash system with a condensing turbine is shown in Figure 3.

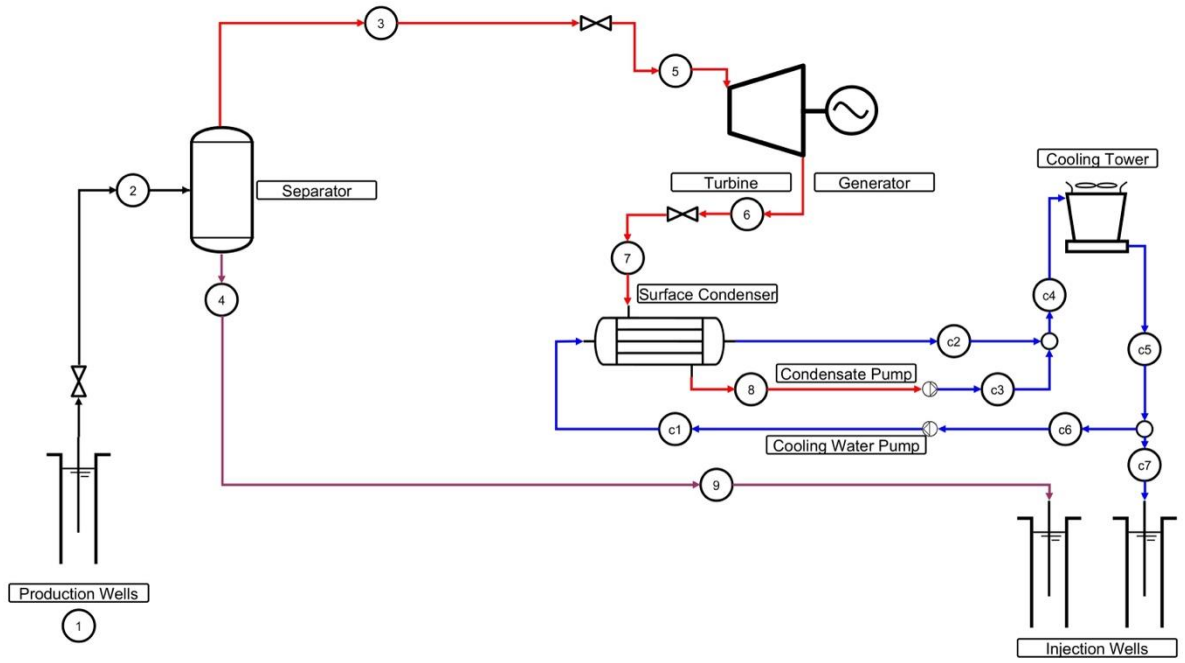


Figure 3: Single flash process schematic diagram

The calculation of thermodynamics temperature-entropy for single flash use equation 1 to equation 11 which is the numbering refer to Figure 3.

$$h_1 = h_2 \tag{1}$$

where h = enthalpy (kJ/kg);

The separation process at a certain pressure, as an isobaric process with quality or steam fraction, x, of the mixture that forms after the separator.

$$x_2 = \frac{h_2 - h_4}{h_3 - h_4} \tag{2}$$

where h = enthalpy (kJ/kg);
x = steam fraction;

The team gain from fraction in point 2 times the total mass flow from wells. The mass of steam ($\dot{m}_3$) can be calculated with Equation 7.

$$\dot{m}_3 = x_2 \, \dot{m}_{total} \tag{3}$$

where $\dot{m}$ = mass flow (kg/s);
x = steam fraction

And the mass flow of separated brine ($\dot{m}_4$) as Equation 8.

$$\dot{m}_4 = (1 - x_2) \, \dot{m}_{total} \tag{4}$$

The gross electrical power developed by the turbine is equal to

$$w_t = n_t \, \dot{m}_s \, (h_5 - h_{7is}) \tag{5}$$

where w_t = Power (kW);
$\dot{m}_s$ = Mass flow of steam (kg/s);

n = Efficiency of turbine (%);
h = Enthalpy (kJ/kg);

In Dieng geothermal field, one well is estimated to have an output of 58 kg/s, then the number of wells required can be obtained as Equation 6.

$$n_{well} = \frac{\dot{m}_{total}}{58} \tag{6}$$

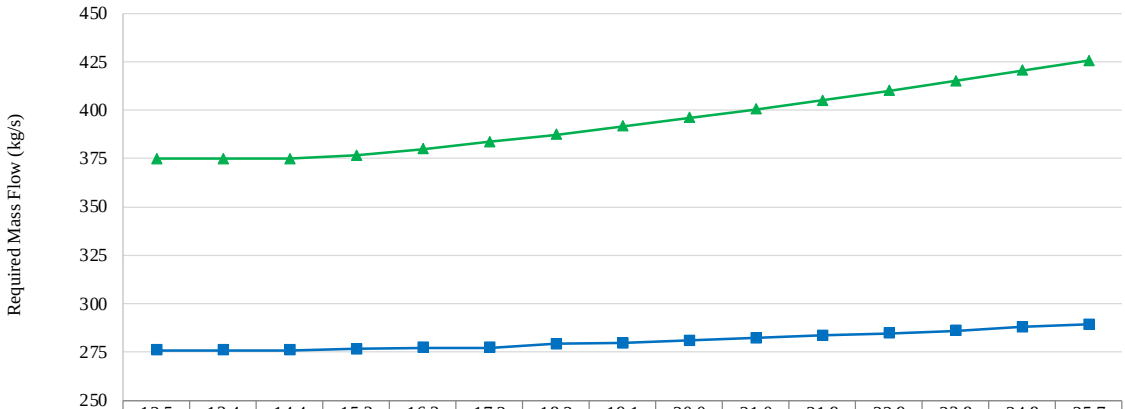
where n_{well} = Number of wells;
$\dot{m}_{total}$ = Mass flow of required geothermal fluids (kg/s);

To study more about the power plant efficiency, the SSC parameter can be used as mentioned in Equation 7.

$$SSC = \frac{\dot{m}_{steam}\ x\ 3600}{w_t} \tag{7}$$

where SSC = Specific Steam Consumption (ton/h/MWnet);
m_{steam} = Mass flow of steam (kg/s);
w_t = Power (kW);

For single flash calculation, the higher the separator pressure, the higher mass flow total from wells but the lower the Specific Steam Consumption (SSC) which can be found in Figure 4.



	12,5	13,4	14,4	15,3	16,3	17,2	18,2	19,1	20,0	21,0	21,9	22,9	23,8	24,8	25,7
Single Flash 1300 kJ/kg	374,8	374,8	374,8	376,7	379,8	383,6	387,4	391,7	396,1	400,5	404,9	409,9	414,9	420,6	425,6
Single Flash 1600 kJ/kg	276,0	276,0	276,0	276,6	277,2	277,2	279,1	279,7	281,0	282,2	283,5	284,7	286,0	287,9	289,1

Figure 4: Mass flow required for Single Flash Configuration

2.2 Double Flash Condensing System

The major component of surface facilities for double flash is similar to single flash with additional such as two separators, high pressure and low pressure, and the steam turbine in two pressure inlets. The simplified schematic diagram for the double flash system with a condensing turbine is shown in Figure 5 which major components consist of separator, turbine, condenser, ejectors or compressors, and cooling tower. There is no demonstration of the double flash in the feasibility study.

A double flash steam plant is another configuration from the single flash design that can increase production by 15-25% with the same geothermal fluid conditions. For larger power ratings, for example, 55 MW or higher, double-flow turbines would be a good choice to minimize the length of the last-stage blades. Usually, the last-stage blades in geothermal turbines are at most 25-27 in (635-686 mm) long (Dipippo, 2012). Double flash design and optimization on lower pressure using Python. It is advised to use the surface condenser, do not dilute the brine with condensate due to the high pH of the condensate will increase the pH of the brine so that silica scaling will start after the condensate injection point. If the injection well for unit 1 still has adequate capacity, it is recommended to dispose of the condensate from Unit 2 with mixing by the Unit 1 condensate well. Condensate should be handled separately from the brine, even if a surface condenser is used. Even if the concentration of dissolved oxygen in the condensate is only parts per billion, the risk of corrosion in the brine system and reinjection wells is too high.

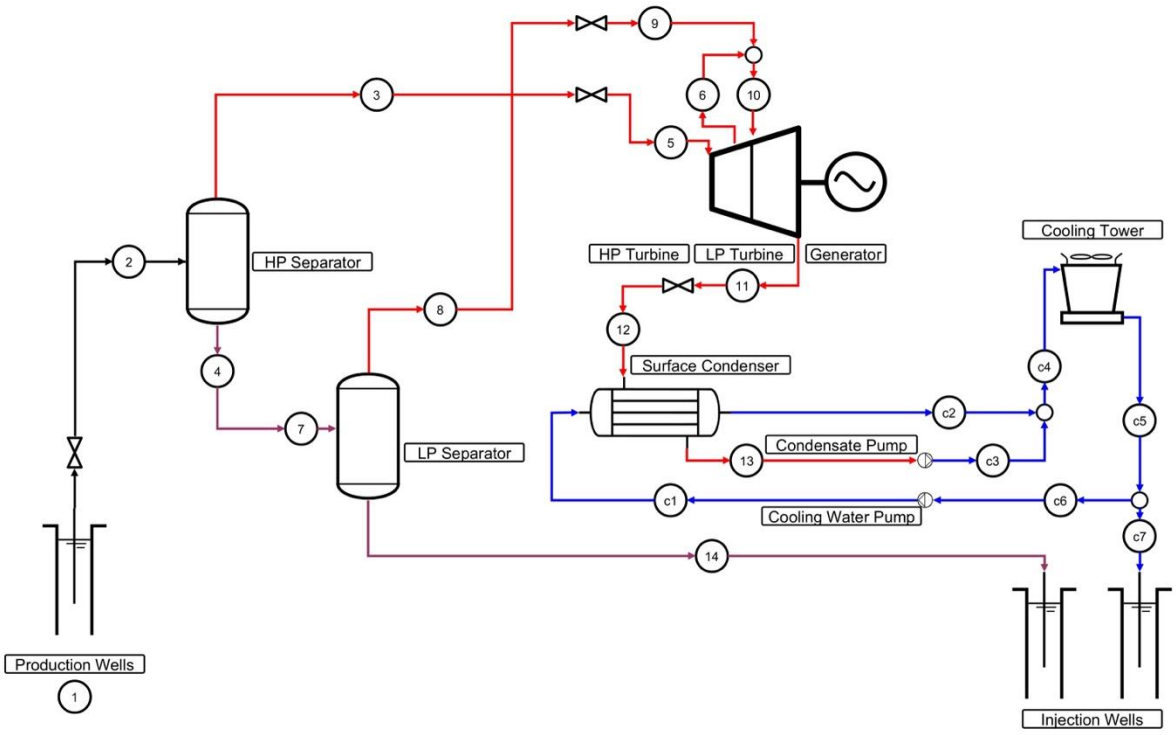


Figure 5: Double flash schematic diagram

The separation process at a certain pressure, as an isobaric process with quality or steam fraction, x, of the mixture that forms after the separator.

$$x_2 = \frac{h_2 - h_4}{h_3 - h_4} \tag{8}$$

where h = enthalpy [kJ/kg];
x = steam fraction;

The steam gain from fraction in point 2 times the total mass flow from wells. The mass of steam ($\dot{m}_3$) can be calculated with Equation 9.

$$\dot{m}_3 = x_2 \, \dot{m}_{total} \tag{9}$$

where $\dot{m}$ = mass flow (kg/s);
x = steam fraction;

And the mass flow of separated brine ($\dot{m}_4$) as Equation 10.

$$\dot{m}_4 = (1 - x_2) \, \dot{m}_{total} \tag{10}$$

The separation process at a certain pressure, as an isobaric process with quality or steam fraction, x, of the mixture that forms after the separator.

$$x_7 = \frac{h_7 - h_{14}}{h_8 - h_{14}} \tag{11}$$

where h = enthalpy (kJ/kg);
x = steam fraction;

The steam gain from fraction in point 2 times the total mass flow from wells. The mass of steam ($\dot{m}_3$) can be calculated with Equation 12.

$$\dot{m}_8 = x_7 \, \dot{m}_{total} \tag{12}$$

where $\dot{m}$ = mass flow (kg/s);

x = steam fraction;

And the mass flow of separated brine ($\dot{m}_4$) as Equation 13.

$$\dot{m}_{14} = (1 - x_7)\, \dot{m}_{total} \tag{13}$$

The gross electrical power developed by the turbine is equal to total power from high pressure with additional power from low pressure with equations 14, 15, and 16 below.

$$w_{HP} = n_t\, \dot{m}_3\, (h_5 - h_6) \tag{14}$$

$$w_{LP} = n_t\, \dot{m}_8\, (h_{10} - h_{11}) \tag{15}$$

$$w_t = w_{tHP} + w_{tLP} \tag{16}$$

where w_t = Total Power (kW);
w_{HP} = Power from HP turbine (kW);
w_{LP} = Power from LP turbine (kW])
$\dot{m}_3$ = Mass flow of steam HP Separtor (kg/s);
$\dot{m}_8$ = Mass flow of steam LP Separtor (kg/s);
n = Efficiency of turbine (%);
h = Enthalpy (kJ/kg);

In Dieng geothermal field, one well is estimated to have an output of 58 kg/s, then the number of wells required can be obtained as Equation 17.

$$n_{well} = \frac{\dot{m}_{total}}{58} \tag{17}$$

where n_{well} = Number of wells;
$\dot{m}_{total}$ = Mass flow of required geothermal fluids (kg/s);

To study more about the power plant efficiency, the SSC parameter can be used as mentioned in Equation 18.

$$SSC = \frac{\dot{m}_{steam}\ x\ 3600}{w_t} \tag{18}$$

where SSC = Specific Steam Consumption (ton/h/MWnet);
m_{steam} = Mass flow of steam (kg/s);
w_t = Power (kW);

The low pressure (LP) of the double flash is is subject to the silica scaling potential as a constraint due to its limits operational pressure. The proposed next tests in the pilot plant should be focused on confirming the minimum allowable separator pressure that achieves manageable scaling levels of silica and aluminium rich-silicate including heavy metals (if any) for flash option. Other than that, the pilot plant test propose to establishing the feasibility of acid dosing to control brine pH and silica deposition rates (test results from first stage tests were inconclusive), define the minimum acceptable second stage flash pressure that the achieves acceptable scaling rates (note that scaling will not be zero, but we need to have a system that only needs to be cleaned out occasionally), the binary combined cycle option to define the minimum acceptable brine outlet temperature that would avoid heavy metal sulfides deposition. Due to the enthalpy of fluids varies from 1300-2100 kJ/kg, in this study, the calculation was also conducted for the 1300 and 1600 kJ/kg enthalpy as Figure 6.

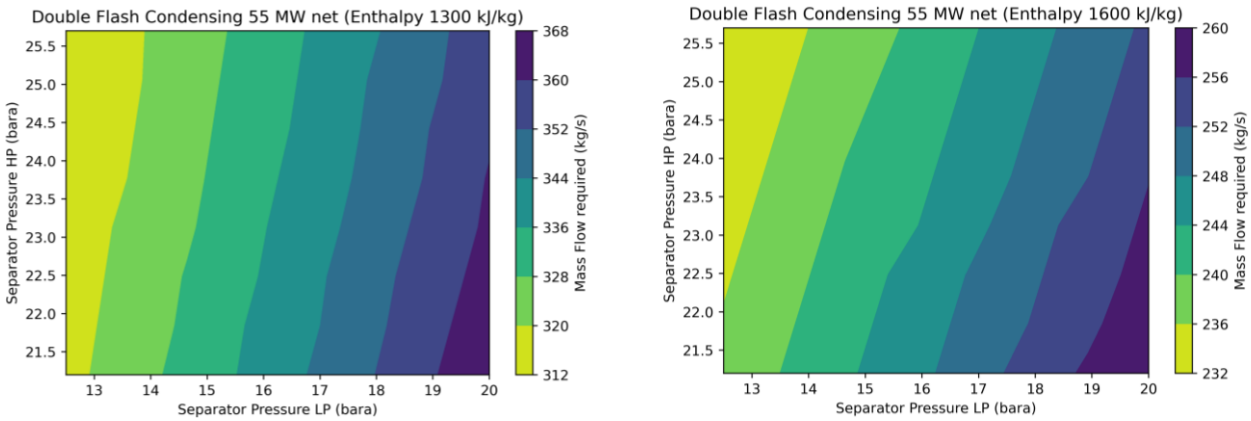


Figure 6: Double flash mass flow for enthalpy 1300 and 1600 kJ/kg

3. DISCUSSION

Geothermal field characteristics are site specific regarding the thermodynamics and chemical contents which make one to another field unique to be developed. Dieng, as one of a brownfield area, already has existing facilities and data, nonetheless needs to be comprehensively studied to have the best approach for the further power plant to improve and adapt to the new technology. Besides, Dieng operating conditions endure for the silica due to its high concentration. To ensure Unit 2 Dieng's design and operation are properly at least for 30 years, the pilot plant testing was conducted as also mentioned and proposed by several previous studies. The pilot plant design and testing were started in 2020. The Figure 7 shows the number of productions well for each alternatives power plant and enthalpy. To be more cost effective, of course the developer will find the way to have the smallest amount of wells. In this case, the findings is we may use less production wells in the double flash condensing type than state before, even using 4 wells. It is of course depends on the output curve of the dedicated wells for Unit 2, but at least using the same assumption in the feasibility study, the number of production wells may be range for 4-7 wells.

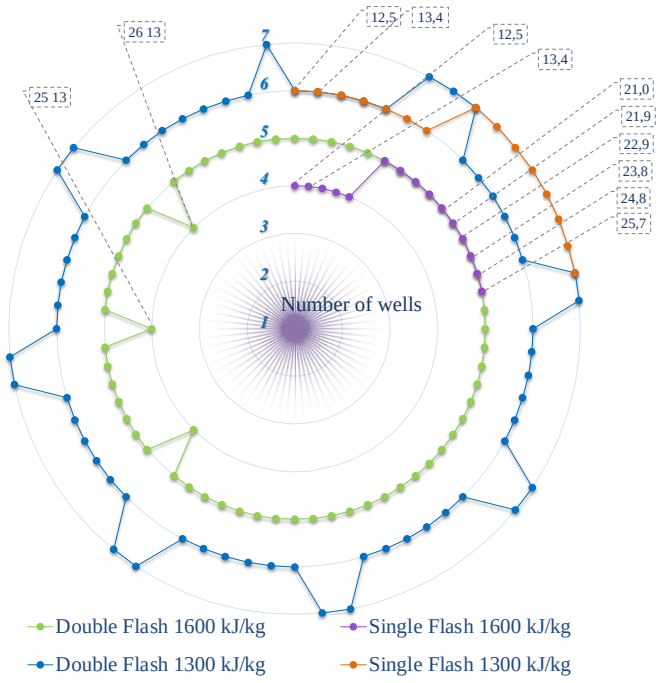


Figure 7: Production wells required

The SSC provided us with any useful information and has decided that it does. Comparing SSC for different plant configurations gives a useful comparison of the complexity of the power plant. Lower SSC means that the power plant is more efficient, and it, therefore, makes sense that SSC is better as the LP flash pressure increases. Note that the best SSC would be for a single flash plant. Even though SSC might be better (and hence power plant costs would be lower) with higher LP flash pressure, the number of wells required to supply the plant would also increase. It is worth to calculating the SSC for the range of options as have done but need to

make sure that state in paper that SSC is only an indicator of the efficiency of the power plant itself. This result can be found in the Figure 8.

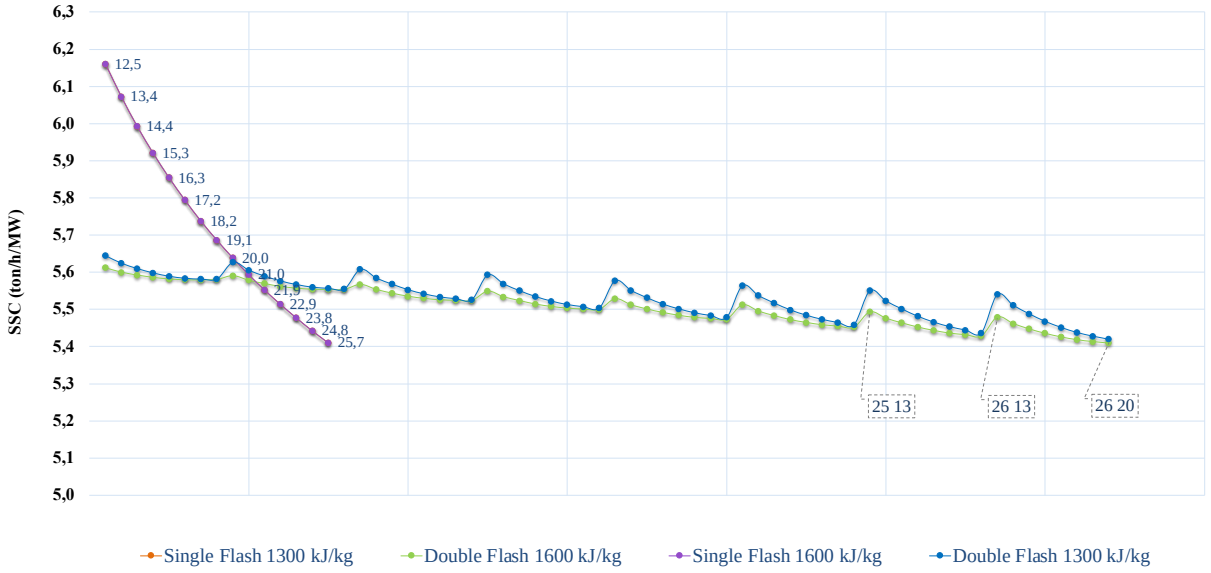


Figure 8: SSC for single flash and double flash configurations

The overall project development costs will be lowest when the total cost of the power plant and the cost of drilling the wells and connecting the SAGS is optimized. The steam consumption in each enthalpy is almost the same using enthalpy 1300 kJ/kg and 1600 kJ/kg, nevertheless, the mass flow from wells has different values which is the lower enthalpy required more mass flow than the higher enthalpy. Another interesting value to be analyse for double flash is additional steam gathered from second flasher or low pressure separator. The higher percentage of steam gathered in low pressure, more advantage can be gained. This result can be found in the Figure 9.

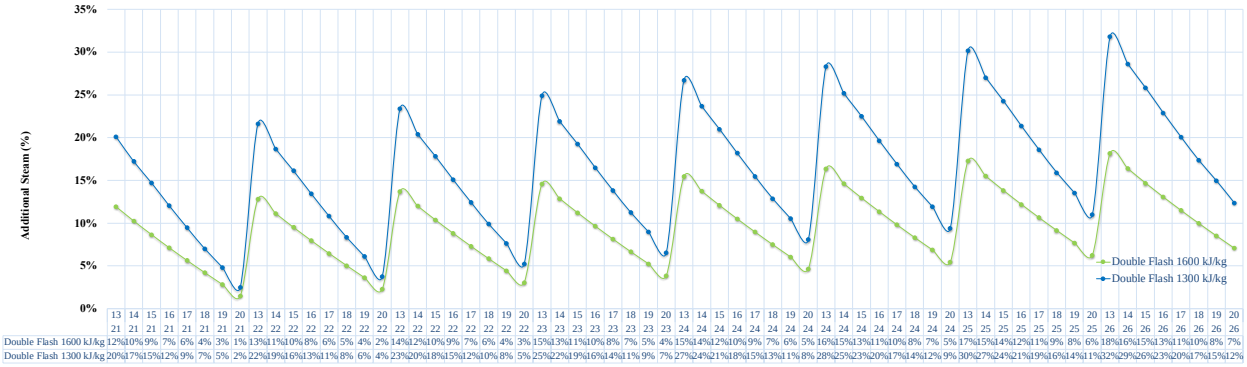


Figure 9: Additional steam for double flash (%)

Other things to consider are for considering the morphology of the pad location and two phases of geothermal fluid type, separator designed are wellhead separator, therefore, the pipeline consists of steam pipelines from well pads to the power plant, brine pipelines from well pads to power plant and pipelines from the power plant to injection wells. If the preferred power plant technology is not the combined cycle, then the pipeline route shall be reconsidered. After the pilot plant study, one of the findings is the use of acid injection to achieve pH modification which leads centralized separation plant that would be preferable to simplify the pH injection system as these can be quite complex. However, the chemistry of the produced fluid varies across the field. Combining the fluids before injecting acid could lead to a higher overall separation pressure than would be the case with well-pad separators. Separator configuration is preferred vertically due to the maintenance effectiveness because a horizontal separator will use a limited platform. For separator selection, further study needs to be conducted, but desk study stated that generally, power plants influenced by New Zealand technology use vertical separators but since the 1990s horizontal gravity separators have been used in Icelandic power plants. First installations in Iceland used vertical separators and in newer installations, horizontal separators have exclusively been used. Experience in the operation of horizontal separators in Icelandic geothermal power plants, which spans decades of operation, is good. Both vertical and horizontal designs can obtain a separator efficiency of 99.9%. The efficiency of the cyclone separator is highly dependent on inflow velocity which achieves the highest efficiency when the steam inlet velocity is between 30 and 40 m/s, at the higher velocity the efficiency decreases rapidly (Thorolfsson, 2020). Injection of CO_2 into the subsurface may cool down the reservoir and the low pH may make the injection line and cause suffering for corrosion. The most appropriate power plant configuration is a

double flash. In the meantime, the most common power plant configuration with high-temperature fields is a single flash condensing system, due to it has a low risk for silica scaling even for the study, the additional power for reservoir temperature 330°C is only 0.4-0.8% (Nugroho, 2011).

4. CONCLUSION

The pilot plant is one of strategy to cope with the silica or other chemical impurities in the geothermal field which is unique from one to another field. Using the proper design of the pilot plant will ensure the operation and testing results can assist the overall steam field and power plant operation parameters with acceptable conditions. The pilot plant design and testing may spend years to find the optimize the proposed design for power plants, but all the processes will help out to sustain power plants' operations for 30 years or more. Several findings in the pilot plant in Dieng field consist of acid injection is not effective in the two-phase line, high pressure, and hot injection may be the selected option for Dieng Unit 2. Other than that, to control heavy metal the test for binary temperature needs to be reconsidered higher. Thermodynamically, the silica saturation index value 1 equals pressure 19 bara, but if the SSI 1.2 is acceptable, the low-pressure turbine recommends higher than 11.57 bara, with the assumption of less than 1 bar pressure loss, the lowest separator pressure proposed 12.5 bara. For the silica scaling rates, the modeling will be taking more time, but as mentioned in the pilot plant result, the scaling rates are 1-2 mm/year. Using the lower pressure of operations relatively will increase the scaling rates. Qualitatively, the scaling rates may be stated as higher than 2 mm/year and need to be tested accordingly.

The power plant configuration used is single flash condensing type and double flash condensing type with enthalpy assumption 1300 kJ/kg and 1600 kJ/kg. Based on this study, the required mass flow for single flash separator pressure ranging from 12.5 bara to 25.7 bara will be 260 kg/s to 405 kg/s with pressure directly proportional to the mass flow required from the wells. While for double flash calculation, the overall required mass flow is ranging from 235 to 360 kg/s and the separator pressure correlation with the mass flow is directly proportional. For Specific Steam Consumption (SSC), the pressure is inversely proportional to the SSC which means the higher the pressure, the lower SSC. The recommendation for the power plant use is double flash using a high-pressure separator of 25 bara and low pressure of 12.5 bara. The second recommendation is a single flash using 25 bara. This recommendation, especially the double flash need to be checked in the pilot plant to gather more comprehensive information about the silica scaling index and silica scaling rates. If this concern is not manageable, then the single flash with 21.2-25 bara separation pressure is recommended. Besides the technical approach, an economical approach to studying the cost difference between the single flash and double flash in Dieng will be interesting.

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