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Water Supply for Big Bore Geothermal Well Drilling: A Case Study in Indonesia

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ABSTRACT

The development drilling campaign for Dieng unit 2 plant has a challenge in its drilling water supply. It is crucial in succeeding geothermal drilling activities. Million gallons of water shall be prepared throughout the drilling project duration. The technical and social aspects are assessed in order to achieve the solutions for the locals and the project. Availability of surface water from the near rivers or lakes should be placed as first priority because such sources are normally in appropriate properties for drilling. As in Indonesia, there are two seasons: rainy and summer, surface water availability is sometimes excessive during rainy seasons, but oppositely, it is deficient during summers. This paper is an assessment of the availability and properties of surface water, brine and condensate use from the geothermal plant byproducts. The study focuses on fluid's availability, toxic material contaminations, dissolved metals. Fluid with environmentally harmful substance shall not be used as base fluid of mud and cement.

1. BACKGROUND

The source of geothermal energy is the almost unlimited amount of heat generated by the Earth's core. Its utilization is considered sustainable for as long as the discharged hot water or steam is reinjected properly into reservoir. Unlike any other resources of new and renewable energy available in Indonesia, geothermal energy is able to sustain the base load throughout a year with negligible CO_2 emissions. As of present days, the investment climate and support from the Government of Indonesia is verily contributing to the acceleration of geothermal energy infrastructures. The government is targeting an average of 860 MWe/year within 6 years.

The development drilling campaign for Dieng unit 2 plant of 60 MWe is one of the recent major national geothermal projects. The project is scheduled for kick-off in early 2021 and completes all the 10 wells in 2023. Million gallons of water are required to complete a single well. The availability of appropriate water supply is a challenge itself. Careful decisions considering technical and social aspects shall be taken.

2. WATER DEMAND

2.1 Drilling Water Demand

A typical big bore geothermal well in Indonesia is a 13-3/8" cemented production or injection casing completed with a 10-3/4" perforated liner in 12-1/4" hole. This type of well size gives the most productivity or injectivity at an insignificant increase in well cost in comparison to standard well size.

Taking an example of one of the wells in the project, SLR-9C in Figure 1. A 26" hole is drilled to 1,496 ft-MD deep for 6.4 days before a 20" surface casing is set in place and cemented. Once the surface section is completed drilled, the next 17-1/2" section is drilled to 5,774 ft-MD for 28.2 days before a production or injection casing is set. A 12-1/4" section or reservoir section follows in subsequent to with 19.9 days of drilling duration up to 9,842 ft-MD. Therefore, during the drilling, a total of 120,489 gallons of calculated wellbore volume is occupied by water. In addition, 84,000 gallons of water of rig's active mud tank shall be prepared. The total active volume is 204,489 gallons. In the industry, 300% of this capacity is prepared. Making the total of 613,467 gallons of water shall be prepared prior to the project.

The analysis from the offset wells in Figure 2 shows that the non-productive time (or NPT) for curing the loss of circulation takes 30.49% (or 75.91 days) of the total amount of NPT. On that account, it is presumed that during the drilling, severe loss of circulation zones are encountered in each section. The demand from wellbore volume is adjusted by 130.49% to 157.226 gallons of water is required. Pump flow capacities of 800 gpm, 900 gpm and 1,200 gpm are prepared for the surface, production, and reservoir section drilling respectively.

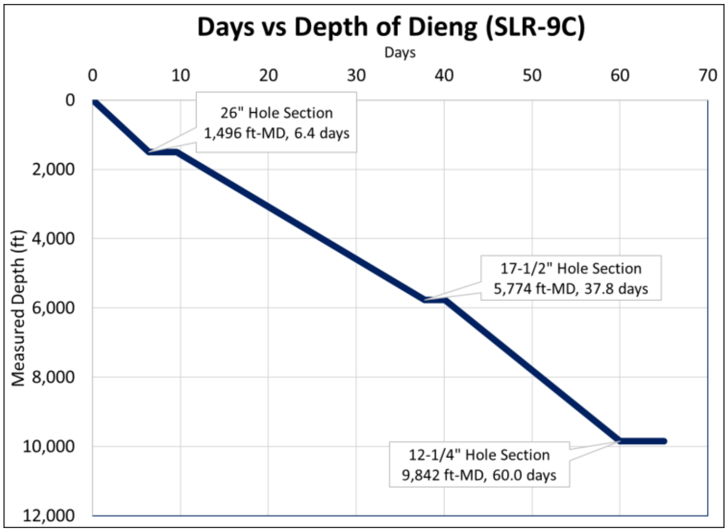

Figure 1 Days vs Depth of Dieng SLR-9C.

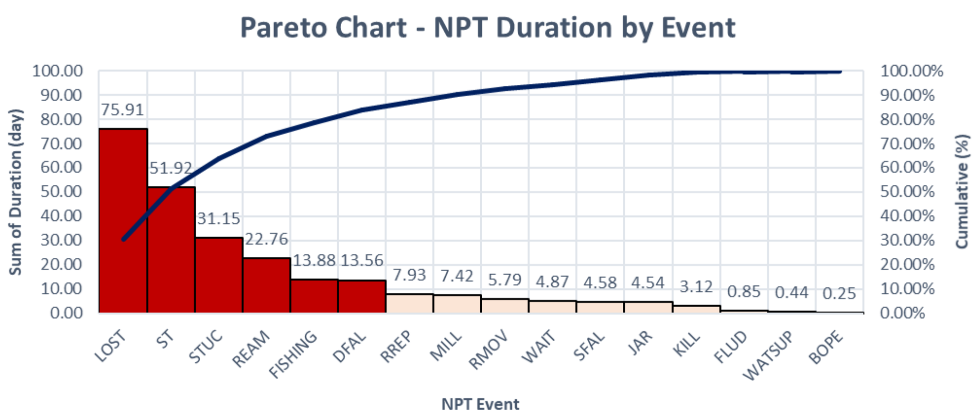

Figure 2 NPT Duration by Event in Pareto Chart

2.2 Cementing Water Demand

A tie-back production or injection casing and cementing technique is in use. This technique may require multiple remedial actions such as squeeze of the 15.8 ppg slurry at 3 times of liner lap volume of 100 bbls each. 300 bbls cement plug is also prepared to combat severe loss zones encountered in 26" surface and 17-1/2" production sections. A detailed calculation of cementing water demand is arranged in Table 1.

Cement type	Slurry volume, bbls	Water mix, %	Water volume, gal
3x cement plug in 26" surface section	300	40%	5,040
26" surface section primary cement	790	40%	13,272
3x cement plug in 17-1/2" production section	300	40%	5,040
17-1/2" production section primary cement	1,110	40%	18,648
Production tie-back	330	40%	5,544
Total	2,830		47,544

Table 1 Water Amount as Bas Fluid for Cement

One of the main objectives of primary cement for both 26" surface and 17-1/2" production section is to achieve reliable shoe with 50 m of length. It is critical as the drilling process will resume to the next section beneath the shoe. It reduces the risk of cement collapse while drilling and to prevent any communication between the pressured zones and the surface.

3. WATER PROPERTIES REQUIREMENT

The water shall have no adverse effects to the environment in regards to the activities and waste of the drilling activity. Its compatibility with mud cement is considerably crucial. Any water source for drilling shall not contain some toxic materials such as Boron [B], Lead [Pb], Arsenic [As], etc. which are harmful to the environment. If such materials are dissolved in the water, several adjustments should meet the following requirements:

1. Should not contain any toxic materials such as Mercury [Hg], Fluorine [F], Boron [B], Arsenic [As], Cadmium [Cd], Almunium [Al], Lead [Pb], etc. due to environmental concern;
2. The dissolved metal such as Fe, Cu, Pb, Zn, and Ag content should not be greater than 75 ppm;
3. The pH of the brine should be more than 5;
4. The density of the brine should not be greater than 8.5 ppg at a temperature of 25 ^{o}C;
5. The brine temperature should not be more than 40 ^{o}C;
6. Total hardness (Ca^{2+} and Mg^{2+}) content should not exceed 100 ppm.

The demanding requirements mentioned above do not allow for any raw and unassessed geothermal byproducts (e.g. brine and condensate) for use as drilling fluid or base fluid for cement. These adjustments are only suitable for making the water feasible to use as drilling fluids/mud. However, the use of such water as base fluid for cement shall be stricter. A common drilling practice uses water as pure as fresh water as the base fluid for cement.

4. THE CASE STUDY

4.1 Social and Culture

Dieng Plateau spans in Wonosobo and Banjarnegara Regencies in Central Java. The Plateau is the second vastest highland in the world after Nepal in the Himalayas. It is renowned for being Indonesia's largest producer of potatoes. No vacant land is left unplanted by the locals, whom predominantly earn their living as potato farmers. The potatoes are harvested every three months where collectors directly buy their yields during harvest seasons. The alluring income made from potato farming has helped the people of Dieng a little alleviated from poverty. A slight mistake on judgement on the use of water for geothermal drilling, it would disrupt harmony with the local community.

Dieng is particularly known amongst the archaeological world as the place where the oldest Hindu Temples in Java were discovered. The Plateau is the location of eight small Hindu temples from the Kalingga Kingdom. It is also home to an annual cultural festival known as Dieng Culture Festival, it presents a variety of art and cultural performances, and an exhibition of Dieng's finest products. This tourism and cultural site infrastructures demand water that cannot be bothered by drilling activities.

The company plans that the project is running in parallel with a workover programme that uses 750 HP rig and requires 1,000 gpm of water. The well workover project is a remediation of wells for the plant's first unit. It was first and last drilled 20s years ago. There are many wells in the pipeline of the workover project. This situation further complicates water share amongst the locals and the projects.

4.2 Water Availability

4.2.1 Surface Water

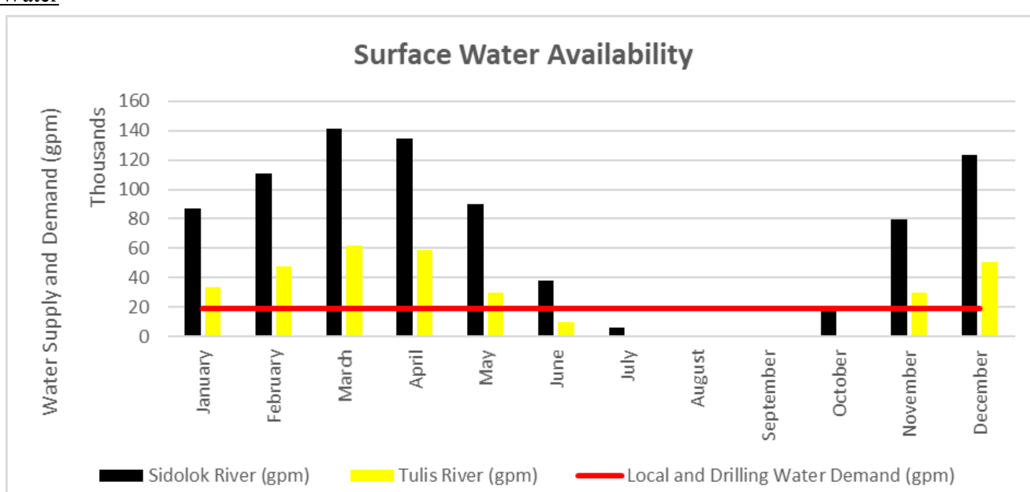

Figure 3 Sidolok River and Tulis River Capacity Rate against Local and Drilling Water Demand (LKFT UGM, 2019)

There are two potential water sources from above the ground, namely Sidolok River and Tulis River. The rivers have neutral acidity and minimum material contaminations. However, both rivers do not give sufficient supply during the summer from June to October, shown in Figure 3.

4.2.2 Brine and Condensate

Brine and condensates are amongst the options. The brine is gathered from atmospheric flash tank (or AFT) at the existing wellpads. Throughout a year, its capacity varies from 1,750 to 2,850 gpm. On the other hand, condensate production is relatively constant at 400 gpm at any time of the year. Figure 4 and 5 depicts brine & condensate production and injection capacity. In February and March, the byproducts injection is greater than the plant produces. Furthermore, based on the study in the observed months, there has never been a sufficient brine and condensate amount for the minimum drilling water supply requirement.

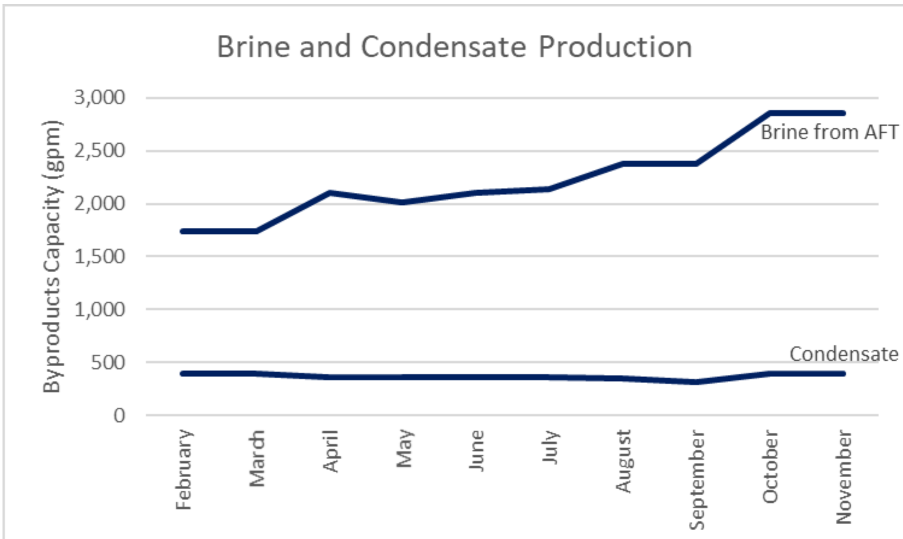

Figure 4 Brine and Condensate Production in a Year (LKFT UGM, 2019)

The brine and condensate contain toxic materials, especially fluorine and boron at high concentration. There are metallic materials dissolved in the water, yet only in a few and tolerable concentrations. Therefore, the byproducts of the plant require special treatment before used as drilling fluid.

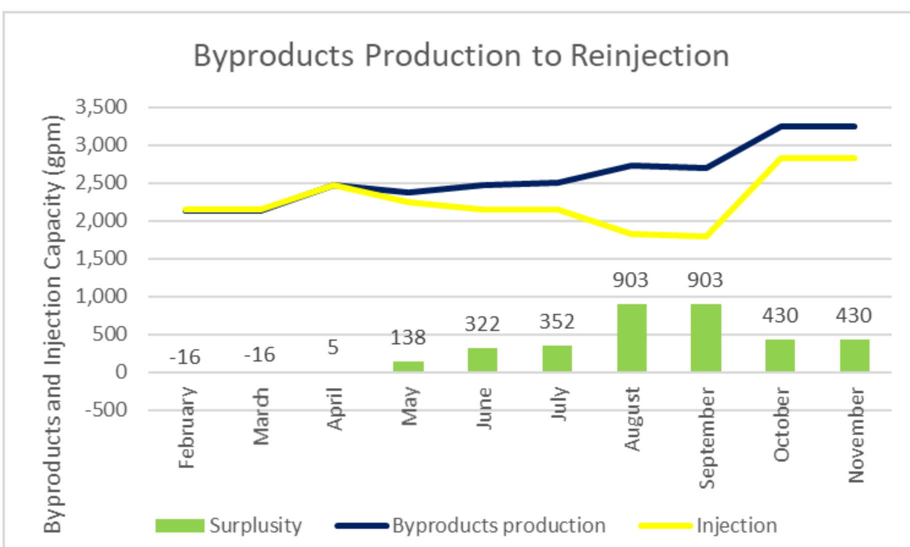

Figure 5 Brine and Condensate Production against Injection in a Year (LKFT UGM, 2019)

5. DISCUSSION

The surface water from Sidolok River and Tulis River are only in sufficient amount for drilling from November to May. The capacity rate of 1,200 gpm of water for drilling through reservoir zone needs to be maintained. That capacity rate has to be available as well for June, July, August, September and October.

The brine and condensate (or the byproducts) were initially considered for use. Yet, with such properties of the byproducts, especially the brine, a complex treatment involving toxic material and dissolved metal removal is required, shown in Figure 6.

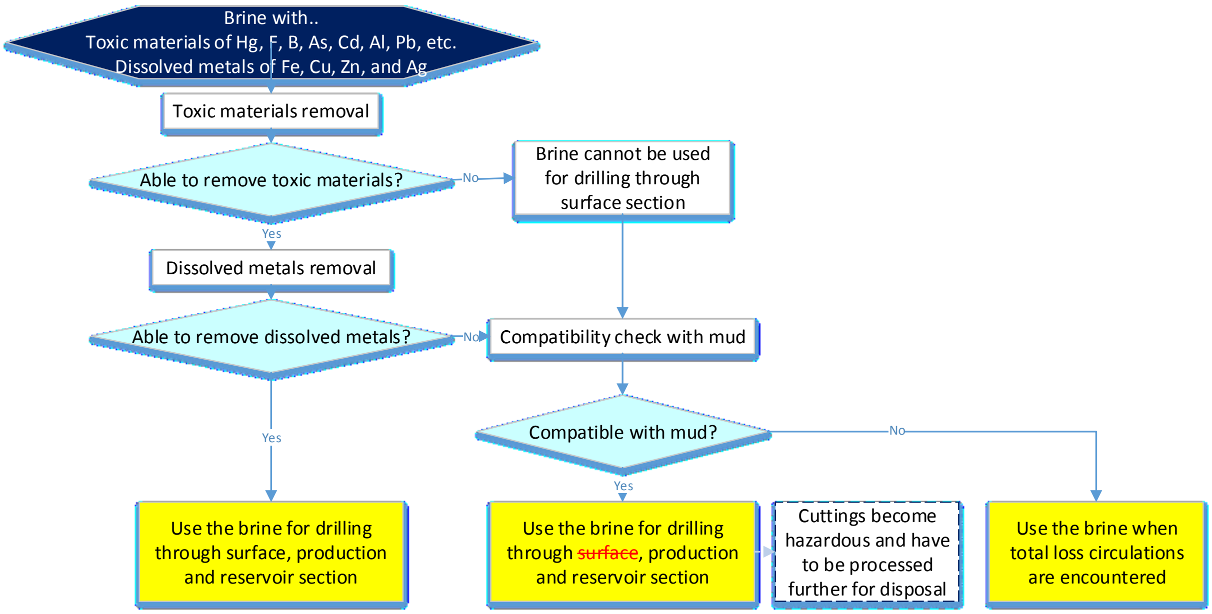

Figure 6 Process of Brine Use as Drilling Fluid

Brine cannot be used as drilling fluid in surface section drilling if either toxic materials or dissolved metals are unremoved. If such brine is used for drilling through production and reservoir section, as long as it is compatible with mud, the cuttings resulted has are hazardous and it has to be processed further for disposal.

The net amount of the injection to the combination between brine and condensate (byproducts) has never satisfied the drilling demand, as shown in Figure 5. As it seems so, workover project may take this condensate during the summers.

Drilling a new water wells has never been an option. The Indonesian environmental protection agency allows only 2.4 gpm of water extraction from water wells due to intention of de-risking lowering ground level.

Making a stock of water from the rainy seasons for use in summers might be an option. In the 5 months of summer (from June to October), 2 new wells are drilled. That means ±2×613,467 gallons or 1,226,934 gallons of water has to be prepared. With a 19.685 feet-deep (or 6 m) water pond limitation due to excavating ability and pump suction head, a 8,332 ft2 pond area shall be set.

5. CONCLUSIONS

Water supply is crucial in succeeding geothermal drilling activities. Million gallons of water shall be prepared throughout the drilling project duration. Availability of surface water from the near rivers or lakes should be placed as first priority because such sources are normally in appropriate properties for drilling.

In Indonesia, there are two seasons: rainy and summer. Surface water availability is excessive during rainy seasons, but oppositely, it is deficient during summers. The development drilling campaign of Dieng power plant unit 2 requires 1,226,934 gallons of water on a 8,332 ft^2 pond area with 19.685 feet (or 6 m) depth.

Brine and condensate as existing plant's byproducts might be used with precautions. Reservoir injection capacity is an important factor to its availability. The properties shall meet the requirements and compatible with mud. However, it is not recommended using geothermal byproduct fluids as base fluid for cement.

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