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Pertamina Geothermal Energy Drilling Campaign 2014 - 2018

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ABSTRACT

After a series of successful drilling campaign between 2007 and 2014, Pertamina Geothermal Energy (PGE) has continued to drill 81 more wells until end of 2018 to support the development and exploration phase of geothermal energy throughout nine working areas. Various challenges have been mapped and defined, corresponded with the escalation of average Total Depth of the wells around 3,000 meters. Thus, several improvements have been carried out to achieve good drilling performance based on ROWC (rate of well completion) and GDUC (geothermal drilling unit cost). Another milestone such as Long String Cement, PDC bit and Casing Drive System which has been implemented recently shows a significant impact to resolve some of the specific challenges faced by the drilling department in PGE. Those improvements are covered not only for engineering design and proper drilling practices but also comprise the contract scheme for services and materials.

1. INTRODUCTION

The exploration of renewable energy resources is the global challenges for future clean energy supply. One of the most reasonable energy developments is geothermal, which is commonly obstructed by economic challenges. Many aspects drive the economic challenges in developing geothermal energy, but it is believed to depend on the drilling well cost mainly. PT PGE, a subsidiary of PT Pertamina as the State-Owned Oil/Energy Company in Indonesia, has become one of the market leaders in developing geothermal working areas, meeting the needs of electrical energy that came from clean source energy across the country. For the last couple of years, many geothermal working areas are being developed in Indonesia where PGE has been involved in eight areas with a total target of 632 MW installed capacity. Three areas that have been on production stages (own operation) consist of Kamojang (West Java), Sibayak (North Sumatera), Lahendong (North Sulawesi) and Ulubelu (Lampung). Whereas five areas are being developed namely Karaha (West Java), Lumut Balai (South Sumatera), Hululais – Bukit Daun (Bengkulu), Sungai Penuh (Jambi) and Tompaso (North Sulawesi). These wide-ranging coverages areas mean consequently impact the difficulty level and various challenges that have to be controlled.

Between 2014 and 2018, PT PGE has completed the drilling campaign in eight different areas, acquiring more than 81 wells of development and makeup well. The drilling performance key indicator is measured in terms of rate of well completion (ROWC) and geothermal drilling unit cost (GDUC), which are fluctuating corresponded with the increasing of Rig Daily Price and total depth. Evaluation for each well has been created continuously to help the engineers analyse the problem thus having the major lesson learned that would be used for the next well. In order to enhance the performance, several improvements have been applied in terms of well engineering design, proper drilling practice and also contractual strategy. By enhancing the performance, PGE is expected to squeeze the overall drilling well cost so that the project will be economically viable. The PGE drilling campaign bar chart shows in Figure 1.

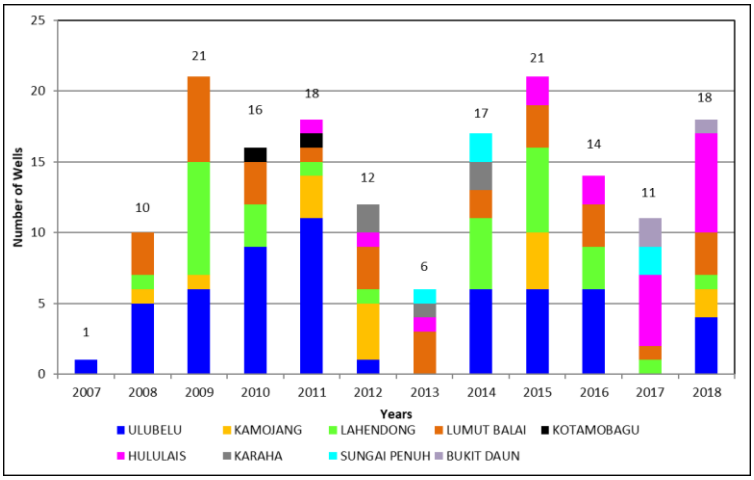


Figure 1: Bar chart of PGE Drilling Campaign Bar chart between 2007 until 2019 shows the number of wells annually.

2. DRILLING CAMPAIGN PERFORMANCE

The PGE roadmap to achieve 672 MWe has continued in 2014, where PGE has drilled about 17 wells as can be seen in Figure 1. It was started with drilling 15 development wells and two exploration wells in Ulubelu, Lumut Balai, Karaha, Kamojang, Lahendong and Sungai Penuh. In the following year, the number of wells increased when the campaign could finish about 21 development wells that spread across five different fields. In 2016, the number of wells was slightly decreased into 14 wells due to landslide and blowout incident in Hululais and Lahendong field respectively. Between 2014 and 2016, the PGE drilling campaign was dominated by drilling production and reinjection wells in Ulubelu and Lahendong field. The main target was to support the development of new Power Plant in Ulubelu Unit III and IV (2 x 55 MW) and also Lahendong unit V and VI (2 x 20 MW). Moreover, PGE could finish 18 more wells in 2018 with the main goals of completing the development wells in Hululais and Lumut Balai Project before the project has shifted into FEED and EPCC phase. All these wells are being monitored carefully in terms of performance and operational execution to provide PGE several wells drilled at a minimum cost.

As mentioned previously in the PGE Drilling Campaign (Zuhro et al., 2015), PGE has developed two criteria to measure the drilling performance quantitatively. It consists of rate of well completion (ROWC) to measure the pace of well completion against the total depth in meter/days unit and geothermal drilling unit cost (GDUC) as a result of total overall well cost (exclude site preparation) divided by total depth in USD/meter unit. Both criteria are indicating that the efficiency of a target depth that can be achieved. The numbers are averagely calculated on an annual basis, showing the performances of each annual drilling campaign. Based on the data between 2014 until 2018, it can be analysed that the average total depth drives both performance criteria. At first glance, the rate of well completion days is increasing in 2014 and 2015 up to 39 m/days compared to 2013, where it only gives 24 m/days. The main challenges in 2014 and 2015 were mostly affected by stuck pipe operation problems. But in 2016 and 2017, the rate is dropping eventually to 33 m/days, even though the NPT stuck pipe operation is reduced significantly. One of the reasons is related to operation strategy while dealing with a loss circulation problem in shallow depth. Over this period of time, PGE has selected the plug and play cementing job method instead of blind drilling considering the well integrity of the well. It consumed a lot of time includes in total drilling days, thus making the overall drilling cost escalated significantly. In addition, the average total depth is increased around ±3000 mMD in 2017, aligned with the declining number of ROWC. It shows that the escalation number of total depths caused the risk of operation to rise exponentially. In 2018, the rate of well completion showed an improvement slope (45 m/days) based on the learning curve from the previous years. On that particular year, PGE has established some improvement that would be explained in the next section of this paper. The annual drilling performances shows by the GDUC and ROWC can be seen in Figure 2.

Since all components that formed the drilling cost structure are made on a daily rate basis, the GDUC number is also directly associated with ROWC. Although, there is a more external variable aspect that was influencing the cost of the geothermal drilling cost. The learning curve in 2014 and 2015 shows a positive slope, where the cost is slightly decreased to 3200 USD/m in comparison to the cost in 2013. In the following years, the cost is rise exponentially into 4000 USD/m, correlated with the declining of ROWC and the escalation of average total depth. In 2018, the GDUC number was considerably improved into 3200 USD/m. Not only the improvement in terms of engineering design and good operation practices but also the changes in contract scheme play a big role in affecting the cost. In 2014, PGE still having a high price in Rig Daily Rate, possibly caused by the high oil price at that time with fewer options of rig availability in the market. However, in 2015 and 2017, along with the falling of the oil prices, PGE has a long-term binding contract with Rig Services with the Rig Daily Rate is reasonably lower than before. Proceeding from the previous years, PGE still using Integrated Project Management (IPM) contract scheme. Although in the mid-semester of 2018, the contract scheme has been modified with all rig and services having a direct and separated contract with PGE. Hence, all daily rates are made as low as possible. The correlation between the rig daily rate and GDUC performances can be seen in Figure 3.

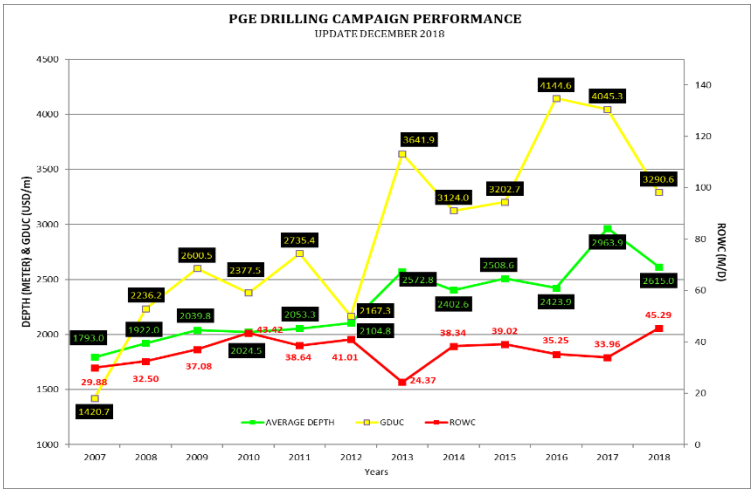


Figure 2: PGE Drilling Campaign Performances in terms of ROWC and GDUC.

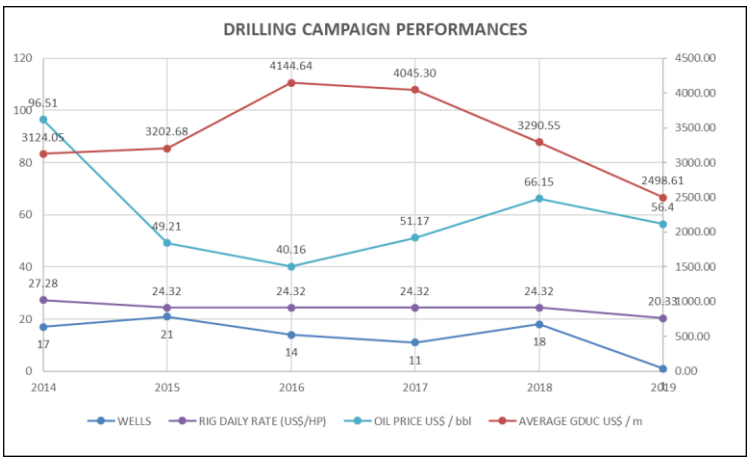
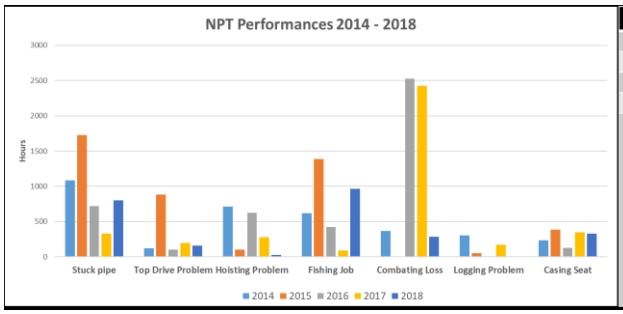


Figure 3: Drilling cost (GDUC) correlated with Rig Daily Rate and Oil Price.

The challenges in terms of minimising the drilling cost are mainly associated with the number of NPT performances of each well, regardless of contract scheme or any other variables that would influence the drilling cost. In 2014, the highest NPT number was contributed by stuck pipe operations and fishing job, along with the other problems. While in 2016 and 2017, since PGE selected the plug and play method for dealing with loss circulation problem, the combating loss is being the most dominant caused of NPT performances. Figure 4 shows the distribution of the greatest number of NPT problems between 2014 and 2018. The identification of subsurface drilling hazard still played the biggest role in causing the NPT performance, whether it caused a stuck pipe operation or combating loss problem in the shallow depth.



PARAMETER	2014	2015	2016	2017	2018
Wells	17	20	14	11	18
Total Operation Days	1002	1297	1069	1088	1138
Total NPT Days	194	228	208	211	144
Percentage	17%	18%	20%	19%	13%
5 TOP NPT	1. Stuck pipe Operations 2. Hoisting problem 3. Fishing job 4. Combating Loss & Cement Plug 5. Logging Problem	1. Stuck Pipe Operations 2. Fishing Job 3. Top Drive Problem 4. Casing Seat Problem 5. Reaming / Backreaming	1. Combating Loss & Cement Plug 2. Stuck Pipe Operations 3. Hoisting Problem 4. Fishing Job 5. Reaming / Backreaming	1. Loss Circ. / Pumping LCM/ Monitor 2. Reaming / Backreaming 3. Stuck pipe operations / jarring 4. Run Casing / Liner Problem 5. Repair Hoisting System Problems	1. Stuck Pipe Operations / Jarring 2. Fishing Operation Unplanned 3. Reaming / Backreaming 4. Run Casing / Liner Problem 5. Lossing Circulation / Pumping LCM / Monitor

Figure 4: NPT Performance between 2014 and 2018.

For all wells between 2014 and 2018, PGE has typical well design, as shown in Figure 5. The well design is adjustable regarding the formation characteristic in some field, but most of it is using the Big Hole design due to the borehole capacity would allow more steam production/fluid reinjection well with higher water fraction (Zuhro et al., 2015). It was a typical Big Hole design with casing 13-3/8 inch as the production casing, following the previous drilling campaign with some improvement in casing selection/design.

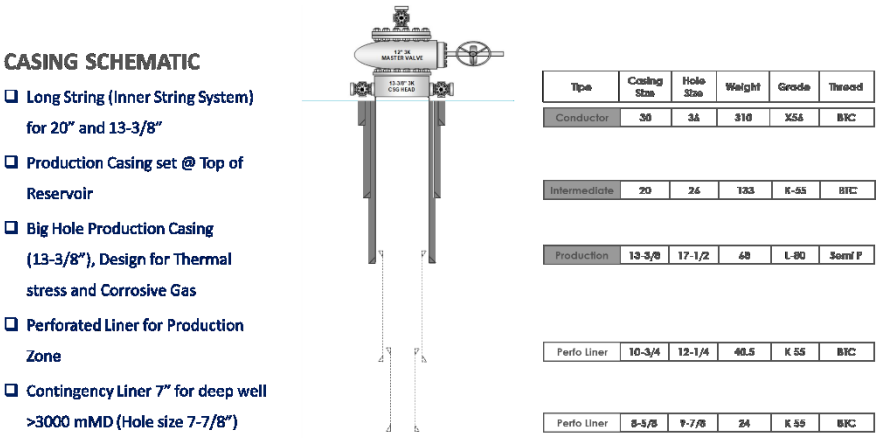


Figure 5: Typical Well Design PGE.

3. LESSONS LEARNED & FURTHER IMPROVEMENTS

3.1 Well Engineering Design

In 2018, some of the improvement had been made to solve the problems faced in previous years. Several issues have been mapped, analysed, and to find the best or proper solutions that can be applied with recent technology available in the market. In terms of well engineering design, there are several lessons learned as follows:

a. Long-String cementing design for 13-3/8 production casing

b. Good aerated engineering design to optimise hole cleaning and increase the penetration rate.

c. PDC bit application for an increased rate of penetration, reducing tripping cost and improved well geometry.

d. Casing while Drilling method for reducing casing seat in production casing.

e. Increase combating loss success ratio: stop loss, flow check, foam cement, soft and hard plug, other material.

f. Use proper drilling practices to reduce casing seat problems such as high rpm rotation, good hole cleaning circulation (rate and time) and special clearance casing.

g. Optimise sweeps pills properties, volume and frequency according to torque and drag roadmap analysis.

h. Optimise KCL usage by conducting CEC and LSM test for the upper section and production section

i. Optimise viscosity material selection through HTHP test for preventing hole permeability damage and waste mud

3.2 Operational Best Practices

On the operational aspect, the proper drilling practices still have a room for improvement in terms of increasing the effective execution. In order to fulfil the cost reduction campaign, some of the improvement has been applied during operation days, such as:

a. Stuck pipe prevention program as a campaign for all personnel involved in the drilling operation, especially for increasing the knowledge and awareness for the rig crew.

b. Prudent quality control and optimum quantity usage control of material and services during operations

c. Optimisation of the number of equipment used such as reduced number of aerated equipment (optimise the usage number of booster and compressor in certain field/Area).

d. Optimisation of the stand by time for services such as aerated stand by time in the upper section, cementing equipment and engineer stand by time in the lower section, etc.

3.3 Contractual Strategy

Contractual Strategy optimisation was delivered with the changing of the contract scenario for several services from Semi IPM Scheme to Individual contract (mud, directional and cementing). It helps PGE to suppress the daily rate of each service without the needs of handling or management fee. In the direct scheme concept, the responsibilities of well design and drilling operations decision are stick to PGE, while each contractor provides the services and materials that have been approved by PGE. The risk of operations has been separated on each side, depends on the type of occurrence. On the contrary, the direct contract scheme pushes PGE drilling department to have prudent supervision for each service and material control. Moreover, in a couple of years, PGE has a plan to optimising the selection of material and services by applying a good standard of ISO, API Q1 and API Q2.

4. CONCLUSION

As a conclusion, Pertamina Geothermal Energy has drilled for more than 180 wells continuously between 2007 and 2018. On the period of 2014 and 2018, 81 wells have been drilled with significant improvement has been applied in dealing with wide-ranging and various subsurface challenges spread in eight different fields. The evaluation has been made in order to have a good learning curve in the next following years based on the ROWC and GDUC criteria. The main goal is to help PGE finished the geothermal project on time, budget and schedule (otobosor) and also keep involved in maintaining steam supply for established PGE Area in the future.

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