# HYDRAULIC RIG AND ITS CHALLENGE TO CONDUCT SLIMHOLE GEOTHERMAL EXPLORATION DRILLING

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## ABSTRACT

Exploration and drilling activity is required to prove the existence of geothermal sources. The result of drilling activity can be used to assess the feasibility of the project. Though, the resource uncertainty, drilling risks, and high costs during exploration activities make investors reluctant to invest. One of the alternatives is by using slim hole drilling instead of big or standard hole drilling. Slim hole drilling has the potential to minimize drilling costs significantly because the equipment, long lead item, and the requirement is less than a big or standard hole.

The hydraulic rig is commonly used in mineral drilling activity and potentially to be utilized in geothermal exploration since the well construction of mineral exploration well is similar to a slim hole well. The capability of the hydraulic rig needs to be assessed to execute slim hole drilling activity. This paper aims to give an overview of hydraulic rig capability to drill the slim hole well. The aspect that will be assessed is the hoisting system, circulating system, foot clamp opening, make-up tool equipment, substructure height, material handling, cementing equipment, and driller's panel or console. The assessment result can provide an alternative and more economical option for drilling exploration in geothermal development, specifically in Indonesia.

## 1. INTRODUCTION

### 1.1 Geothermal Target in Indonesia

Refers to Presidential decree 22/2017 (Perpres No. 22/2017), the Indonesian government, through Kementerian EBTKE has target 7,200 MW of geothermal capacity in 2025 ( (Direktorat Panas Bumi, 2020))

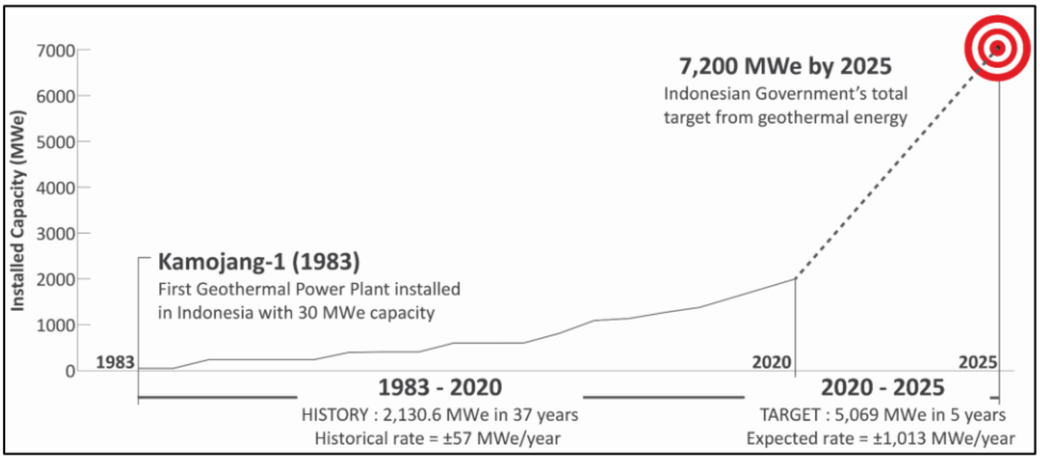


**Figure 1 Indonesia geothermal power plant installed capacity and the government's target in 2025 (EBTKE, 2020)**

The target shown on Figure 1 looks so ambitious if not accompanied by massive exploration drilling activity. Though, the resource uncertainty, drilling risks, and high costs make exploration drilling is difficult to conduct. Investors are reluctant to invest due to uncertainty. The exploration activity itself may contribute up to 20% of the total project cost, where the main contributor to this high cost is the exploration drilling (Direktorat Panas Bumi, 2020). To minimize exploration costs, one of the alternatives is by using slim hole drilling instead of big or standard hole drilling. Slim hole drilling has the potential to minimize drilling costs significantly because the equipment, long lead item, and the requirement is less than a big or standard hole.

### 1.2 Slimhole Well as an Exploration Well

Exploration well are purposed to obtain subsurface geological information of a geothermal field, make connections of temperature and permeability to the geological structure and the adjacent area. Exploration well can confirm subsurface information of geothermal prospects.

Indonesian government has already define the geothermal well type from the aspect of size and objective through the Indonesian National standard (SNI) 7985 2015. The well design type can be seen in Figure 2

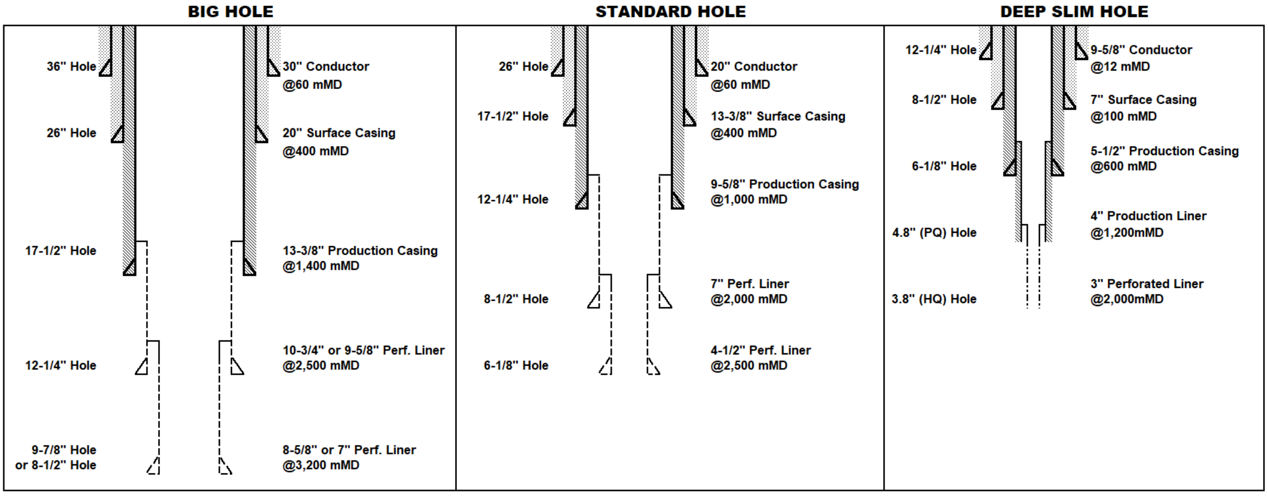


**Figure 2 Types of geothermal exploration well ( (PT. Rigsis Energi Indonesia, 2021))**

Slim hole drilling is suitable for high-risk geothermal exploration with condition (Eko, 2018) :

1. Difficult terrain,
2. Highly uncertainty of resources,
3. Small capital budget

However, slim hole drilling may need a longer drilling time because it requires complete coring during drilling.

## 2. SLIM HOLE DRILLING REQUIREMENT CASE STUDY IN EAST INDONESIA

### 2.1 Well design

The data used to construct this assessment is based on Well Design on Figure 3~~Figure 3~~

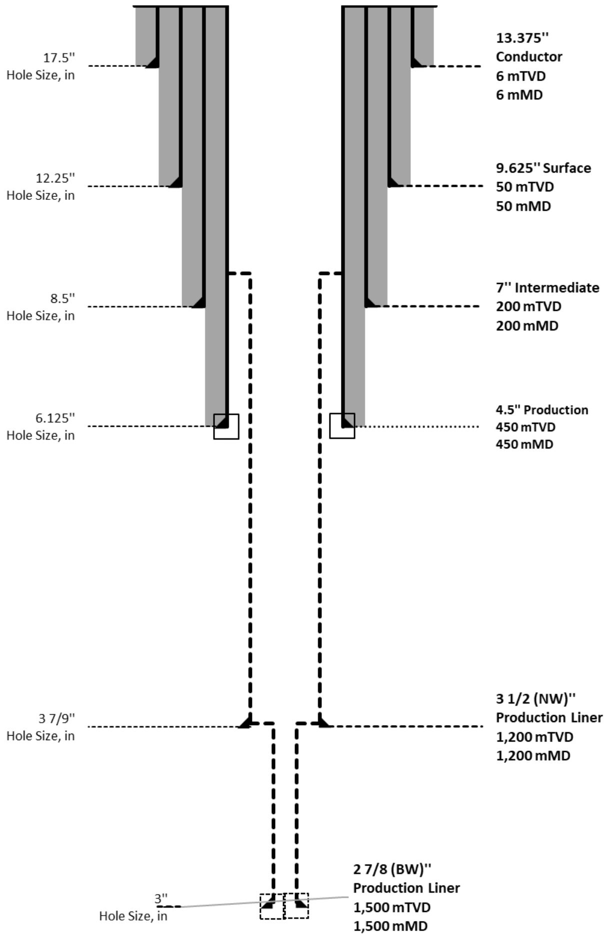


**Figure 3 Well Design as Basis of Assessment**

The production section will be drilled with a coring rod and diamond coring bit with size HQ (3 7/9") and NQ (3"). HQ and NQ size is commonly used in mining drilling.

### 2.2 Mining Rig Assessment

The aspects of rig that will be evaluated include:

1. Hoisting system
2. Circulating system
3. Foot clamp opening
4. Makeup tool and material handling equipment
5. Substructure height
6. Driller's panel or console

#### 2.2.1 Hoisting System

A mining rig is classified as a hydraulic rig, as illustrated in Figure 4~~Figure 4~~ . Hydraulic Rig is different to conventional rig in the geothermal drilling industry due to the absence of draw work as main hoisting equipment. Since draw work is not used, rig capacity cannot be solely defined by the horsepower of drawn work. Pullback and pulldown capacity are common terms used to define hydraulic rig hoisting capacity. Hydraulic jack is used as main hoisting equipment, energized by the pressure of the hydraulic fluid



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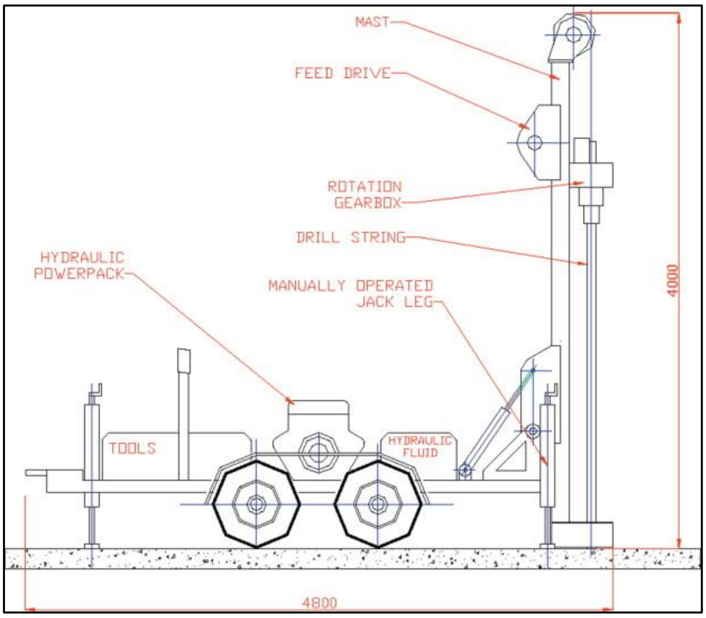


**Figure 4 Hydraulic rig**

The requirement of hoisting system for each section is shown in Table 1~~Table 1~~

**Table 1 Load Summary**

| Static Load Summary | | | | | |
|---|---|---|---|---|---|
| BHA Load | | | Casing Load | | |
| BHA 12 1/4" (50m) | 8,471 lb | 3,580 kg | Running 9-5/8" casing (50m) | 6,377 lb | 2,892 kg |
| BHA 8-1/2" (200m) | 24,126 lb | 14,446 kg | Running 7" casing (200m) | 13,385 lb | 6,070 kg |
| BHA 6-1/8" (450) | 26,476 lb | 16,735 kg | Running 4-1/2" Casing (450) | 17,125 lb | 7,766 kg |
| | | | Running NW" Liner (445-1200) | 21,161 lb | 9,597 kg |
| | | | Running BW" Liner (1,195 - 1500m) | 6,889 lb | 3,124 kg |
| Heaviest Load | | | | 26,476 lb | |
| Heaviest Load + safety factor 20% | | | | 31,771 lb | |

As shown in Table 1, BHA load and casing load will be at its maximum during drilling 6-1/8" with 26,476 lbs and if included, the safety factor is 31,771 lbs. The heaviest load plus safety is the minimum pullback capacity requirement for a mining rig.

### 2.2.2 Circulating System

Circulation system has the function to circulate drilling fluid through the drill string and up the annulus for carrying cutting. The circulating system in this drilling campaign is very important during enlarged activity because the drilling fluid will be carrying the drilling cutting.

The flow rate of drilling fluid during enlargement has been calculated for each section, starting from section 12-1/4", 8-1/2", 6-1/8", and in the case we encounter partial or total loss circulation. Flowrate result for each section shown in Table 2~~Table 2~~.

**Table 2 Flowrate during rotary drilling**

| Hole Section | Flowrate |
|---|---|
| 12-1/4" | 450 gpm |
| 8-1/2" | 220 gpm |
| 6-1/8" | 165 gpm |
| Encounter loss | 700 gpm |

Circulating system to support the flowrate from Table 2~~Table 2~~ must be consist of a pump manifold, standpipe, kelly hose, swivel, and top drive because flowrate and pressure that will be pumping are quite high. Circulating system equipment is shown in Figure 5.

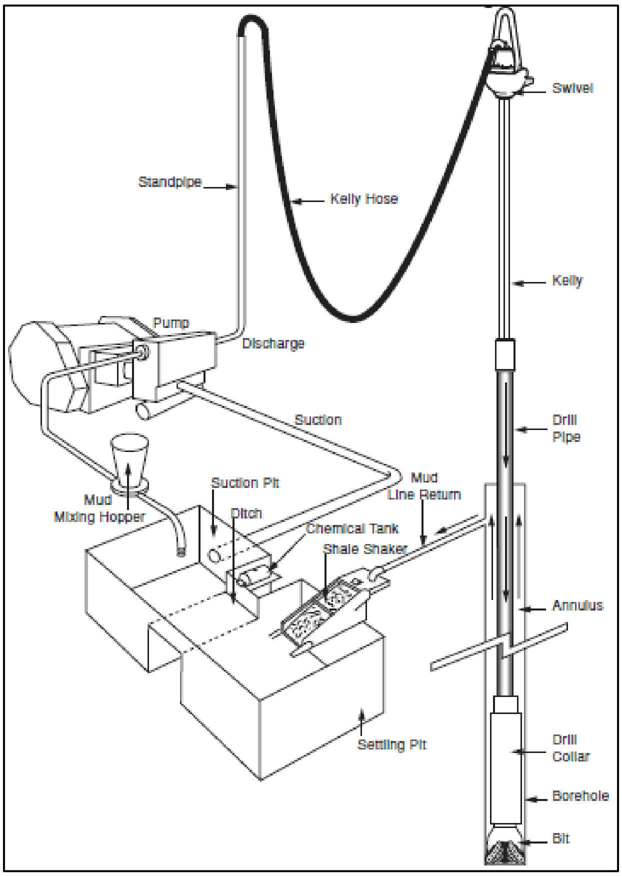


**Figure 5 Circulating System ( (Heriot Watt University, 2000))**

Tanks for circulating are divided into four types. Such as:

1. Trip tank
   Trip tank is a small tank, and it can effectively detect volume changes. The trip tank system can continuously fill the well and take the return to the tank.
2. Shaker Tank
   A Shaker tank is a tank to mud after filtered from cutting with the shale shaker. The rig should provide a trip tank with a capacity around 100-125 bbls.
3. Active Tank
   An active tank is a tank of mud that is ready to pump to the well. The rig should provide an active tank with a capacity around 250 bbls.
4. Mud pit
   Mud pits are used to store waste mud and cuttings prior to disposal and remediation of the site of the pit. The rig should provide a mud pit with a capacity around 25-37.5 m3 or 158 – 236 bbl.

### 2.2.3 Makeup and handling tool equipment

Definitions of "Make Up" are to tighten threaded connections and to connect tools or tubular by assembling the threaded connections incorporated at either end of every tool and tubular. The threaded tool joints must be correctly identified and then torqued to the correct value to ensure a secure tool string without damaging the tool or tubular body.

Refer to the mining rig;the top drive is used to make up activity has a maximum torque of 9,970 Nm, without any other means such as power tong or iron roughneck commonly found in geothermal drilling. The highest torque that will be encountered is during make-up 6-1/2" drill collar (46,233 Nm). This information confirms that the top drive did not meet the minimum requirement. Therefore, the mining rig should provide makeup equipment as per the minimum requirement.

Due to the proposed BHA design and casing design, several make-up tools that must be available in the rig is detailed in Table 3~~Table 3~~. The rig should provide those tools or any equivalent tools to be able to handle the mentioned pipe or BHA component size.

**Table 3 Handling and Make-Up Tool Equipment. The rig should provide those tools or any equivalent tools to be able to handle the mentioned pipe or BHA component size.**

| | Tools name | Description |
|---|---|---|
| 1 | Rotary Tong | Available for 3-1/2" up to 8" size pipe |
| 2 | Coring Tong | Available for all coring road size |
| 3 | Pipe Spinner | As Pipe specification |
| 4 | Pipe Slips | Rotary slip for 3-1/2" up to 8" size pipe. |
| 5 | Multi-Segment DC Slips | For DC size 4-3/4", 61/2" |
| 6 | Safety Clamps | For DC size 4-3/4", 61/2" |
| 7 | Lifting Subs | For DC size 4-3/4", 61/2" |
| 8 | Bit Subs | For bit size 6-1/8", 8-1/2" and 12-1/4" ,17-1/2" |
| 9 | Bit Breaker | For bit size 5-1/2" up to 12-1/4" |
| 10 | Bit Stabilizer | For bit size 6-1/8", 8-1/2" and 12-1/4" ,17-1/2" |
| 11 | Bit ring gauge | For bit size 5-1/2" up to 12-1/4" |
| 12 | Pipe box for DP, DC | Tubulars box should be available. |
| 13 | Hydraulic Casing Power Tong | Available for casing 9-5/8" & 7", 4-1/2" completed with power unit & spare dies |
| 14 | Casing Slip | For All sizes of casing |
| 15 | Hydraulic Drill Pipe Power Tong | Fits for Drill Pipe 5 in and 3-1/2 in, Drill Collar 6-1/2 in and 4-3/4 in. |
| 16 | Hydraulic Coring Pipe Power Tong | It fits for all coring Rod, PW, HW, NW, BW |
| 17 | Elevators / hoisting plug / lifting sub or equivalent.<br><br>Hoisting plug or lifting sub will be design based on conection that will be used during drilling. | 1 (one) ea 3-1/2" DP elevator/lifting sub/equivalent |
| | | 1 (one) ea 5" DP elevator/lifting sub/equivalent |
| | | 1 (one) ea 4.5" Casing elevator/lifting sub/equivalent |
| | | 1 (one) ea 7" Casing elevator/lifting sub/equivalent |
| | | 1 (one) ea 9-5/8" Casing elevator/lifting sub/equivalent |
| | | 1 (one) ea 13-5/8" Casing elevator/lifting sub/ equivalent |

### 2.2.4 Foot clamp Opening

The size of a rotary table or foot clamp opening is to identify the minimum equipment or pipe that can pass through the rotary table. Refer to mining rig Specification. Maximum foot clamp opening is SW (~7"), Rig must have a minimum opening foot clamp to accommodate 13-3/8" casing (the largest casing used). This information confirms that the opening table does not meet the minimum requirement. The mining rig should provide a foot clamp as per the minimum requirement.

### 2.2.5 Substructure Height

During drilling operation, the height of the substructure is dictated by the height of the wellhead and blowout preventer assembly. The mining rig that assessed did not have a substructure, because rig is placed on the ground, Rig must have minimum substructure height to accommodate BOP in section HQ and NQ (19 ft). The summary of BOP height for each section is mentioned in Table 3Table 3.

**Table 4 BOP stack height (height of ram and annular refers to(T3 Energy Services, 2020) (National OilWell Varco, 2020))**

| Section | BOP stack height | |
|---|---|---|
| 8-1/2” | 13.9 ft | 4.24 m |
| 6-1/8” | 15.4 ft | 4.71 m |
| HQ and NQ | 19 ft | 5.79 m |

To minimize the substructure height, the BOP stack can be placed in the cellar. So, the BOP stack can be accommodated by a cellar plus substructure.

### 2.2.6 Driller’s Panel or console

This panel is used for control and monitoring the drilling parameter during drilling. The mining rig commonly has driller panel conditions such as:

1. No string weight indicator in ton or lbs (only in psi)
2. Torque reading (for makeup or drilling) in psi
3. No depth sensor
4. No RPM counters
5. No pump SPM counter

**Figure 6 Drilling Console in a mining rig**

To provide drilling console in proper condition, Rig services should convert the measured parameter into the appropriate unit (e.g., torque in-lbs.ft or N.m, weight in lbs or ton.).

## 2. CONCLUSION AND SUMMARY

Mining rig capable of drilling slim hole well, because pullback capacity of mining rig meet the requirement. But there are modification and additional equipment on the mining rig that needs to be fulfilled.

The assessment summary of the mining rig is shown in the table below

| Description | Minimum Requirement | Mining Rig Specification | Remarks |
|---|---|---|---|
| **Hoisting System** | 31,771 lbs for 6-1/8" hole drilling to 450 m | 44,000 lbs | Meet the requirement |
| **Circulating System** | 700 gpm | 37.4 gpm | Not meet the requirement |
| **Foot clamp opening** | 13-3/8" | SW (~7") | Not meet the requirement |
| **Makeup tool equipment** | Minimum torque 46,233 Nm to make up 6-1/2" Drill Collar | maximum torque of KL900 9,970Nm | Not meet the requirement |
| **Substructure height** | 19 ft<br><br>(5.8 m) | - | Not meet the requirement |
| **Material Handling** | Equipment with the capability to handle DC 6-1/2" (979 lbs) from pipe rack to rig floor / catwalk | Manual Handling | Not meet the requirement |
| **Driller panel or console** | Drilling parameter (weight in lbs, torque in-lbs.ft, flowrate in GPM, etc.) depth sensor, RPM counter, pump SPM counter | All the parameters using psi, no depth sensor, no RPM counter, no SPM counter. | Not meet the requirement |

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