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GEOTHERMAL DRILLING AT OLKARIA FIELD

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ABSTRACT

Olkaria geothermal field is one of the many geothermal prospects in Kenya and is located within the rift valley. It is the most developed of all the fields in Kenya. The field is owned and operated by the Kenya Electricity Generating Company PLC. Geothermal drilling at Olkaria is a journey of more than half a century.

1. INTRODUCTION

Drilling is the process of making a hole through the earth in order to access resources in this case hot fluids located at depths below the earth's surface. Whereas all other exploration activities are of great significance drilling is the only activity that actually confirms availability of a resource. Successfully drilling is therefore of great significance.

The Olkaria geothermal field is one of the many geothermal prospects in Kenya and is located within the rift valley. It is the most developed of all the fields in Kenya. The field is owned and operated by the Kenya Electricity Generating company limited (KenGen). Geothermal drilling at Olkaria is a journey of more than half a century.

Drilling at Olkaria commenced in the 1950's with two exploratory wells which unfortunately didn't give any promising results despite being successfully drilled to target depths. Subsequent studies and drilling has been done in various areas of the field with great success leading to development of various power plants. Currently the project has over 290 wells drilled most of which are active production wells

The wells are drilled to depths of 3000 m though wells drilled in the 90's and early 2000 were to depths of 2200 m. The average drilling days is 55 days. KenGen owns and operates three drilling rigs at the Olkaria field-two of which are 2000 Hp electric land rigs capable of drilling up to 7000m whereas the other is a 550 Hp mechanical rig with a drilling capability of 2200 m.

2. OLKARIA WELL DESIGN

Prior to commencing any drilling works the well siting team which comprises experts drawn from all the geosciences will identify the best location to be drilled. This is based on the resource models developed for the field. The infrastructure team will then come in to prepare the site ensuring accesability,availability of water and a pad for mounting the rig; this is followed up by rig mobilization and rigging up.

The onset of drilling technically known as spudding is preceded by a technical meeting know as pre-spud meeting whereby all teams to be involved in the drilling have a brainstorming session and undertake *drilling on paper*. **Drilling on paper** involves going through the entire drilling process from zero depth to rig release on paper and analysing any challenges anticipated. It is also a session of taking stock of all material and tools required and status of the equipment to be utilised.

At Olkaria regular size wells are drilled consisting of both directional and vertical profiles.
A typical geothermal well at Olkaria is drilled to a depth of 3000m and the drilling is done in phases as follows:

i. **Conductor casing**: This is installed after excavating the cellar and is normally a 30″ casing set up to 10-30 m depth.
ii. **Surface hole**: Drilled using a 26″ bit up to depth of 60 m, a 20″casing is then run in hole and cemented to surface.
iii. **Intermediate hole/anchor hole:** Drilled to 300 m using 17-1/2″ bit, a 13-3/8″ casing is run in hole and cemented in place all the way to the surface.
iv. **Production hole:** Drilled using 12-1/4″ bit to depths ranging between 700-1200 m depending on the well prognosis and wellbore geology logs done during the actual drilling. The section is cased using a 9-5/8″ casing and cemented to the surface.
v. **Main hole:** Drilled from the production hole normally depths ranging from 700/1200-3000 m using an 8-1/2″ bit. The section is then cased using 7″ slotted liners which are squatted at the bottom. These are not cemented in place and are not run all the way to the surface. They are run to extend inside the previously cased hole normally the 9- 5/8″ casing by 22 m. The top two liners are plain (non-perforated 7″ liners) with the first one flared to allow for ease of running in logging tools.

Table 1 shows a summary of the well design at Olkaria including the drilling fluids utilised.

TABLE 1: Olkaria well design

Name	**Hole size, inch**	**Casing size**	**Depth**	**Casing**	**Recommended drilling fluid**
Surface Hole	26	20	50-60	94ppf K-55	Bentonite based mud
Intermediate	17-1/2	13-3/8	300	68/54.5ppf	Bentonite based mud, switch to aerated drilling in case of loss
Production	12-1/4	9-5/8	750-1200	47ppf	Bentonite based mud-aerated drilling
Main hole	8-1/2	7	1200-3000	26ppf	Aerated drilling fluids

3. DRILLING PERFORMANCE

The average drilling days for a 3000 m well in Olkaria ranges from 55-60 days. This is subject to formation challenges and availability of materials, equipment among others. It is important to note that the number of drilling days is a key determinant of the cost of a well. The average cost of a well stands at 5-7 MUSD, of this over 50% is controlled by the number of days spent on a well.

A lot of effort has been put in improving drilling performance at Olkaria with the aim of delivering quality wells within the shortest time possible. This has seen reduction of drilling days for a 3000 m

well from over 150 days to ranges between 50-90 days. Cases of wells drilled in less than 50 days have been observed in the recent years. This success can be attributed to; well trained and experienced personnel, better drilling technology and a broad understanding of the various formation types present within the Olkaria field. Table 2 shows the recent wells drilled in Olkaria, whereas Figure 1 is a graph showing the average number of wells drilled per year.

TABLE 2: Wells drilled at Olkaria

Description of wells (Recent past)	**Number of wells**
Appraisal wells	6
15 Wells Contract	15
10 Wells Contract	10
26 Wells Contract	26
2 Wells Contract	2
Wells drilled by N370 rig	18
Wells drilled by 2 new KenGen Electrical rigs	36
Wells drilled under 80 wells Contract	89
Total wells drilled to completion	202

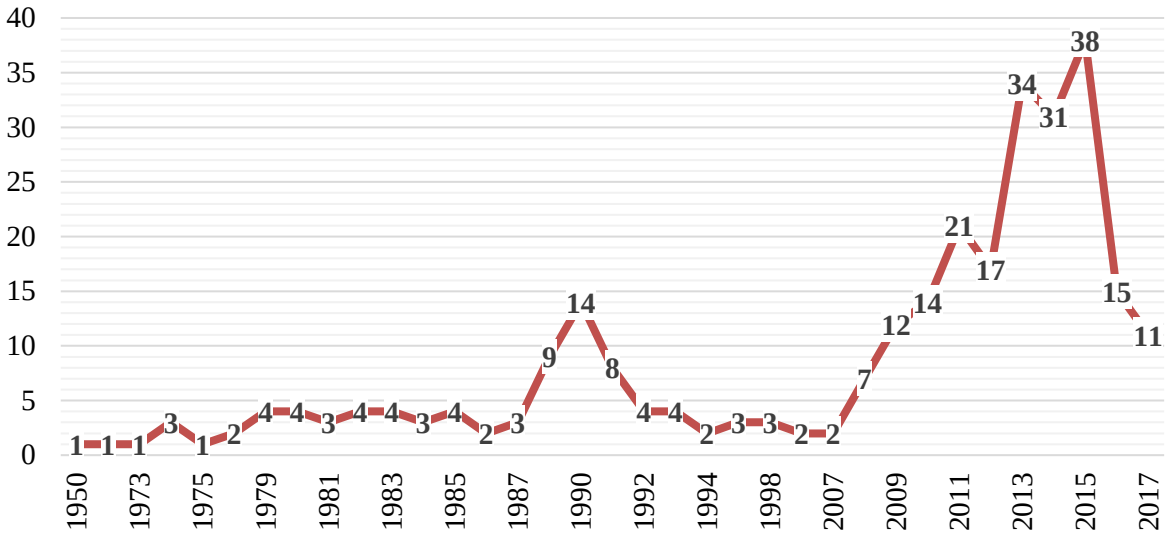

FIGURE 1: Graph of number of wells drilled at Olkaria per year

4. DRILLING CHALLENGES

As discussed earlier, drilling is one of the most costly elements in geothermal development. A 3000 m well costs on average between 5-7 MUSD. The biggest component of this cost is based on number of days taken in drilling the well. This implies emphasize should be made on eliminating or reducing any challenge that tends to increase days per well. Common drilling challenges encountered at the Olkaria geothermal field include:

i. *Formation challenges*: This can range from soft collapsing formation to hard formations which are almost impossible to drill through. A soft formation possess the risk of poor hole cleaning due to high rates of penetration(ROP).Poor hole cleaning is a major contributor to stuck pipe and hence fishing.Experinece has led to setting the maximum ROP in soft formation to 10m/hr with a cleaning period of at least half an hour after every 10 m. This reduces chances of

accumulation of cuttings around the string. On the other hand hard formations result in increased rate of bit wear and hence several trips necessitated for bit change. This is corrected by better bit selection to ensure hard formation bits are utilised in these areas. Other challenges accustomed by formation types are loss of circulation which will lead to ; stuck pipe, several cementing jobs, loss of drilling fluid (hence expense).

ii. *High formation temperatures*: Geothermal drilling involves cutting through high temperature zones, this poses a challenge of increased wear for the bit and rig equipment. Pump liners experience high wear rates at high temperatures. Bearings on the bits are easily damaged at high temperatures. Selection of bits with extra protection for the bearings is key to correct this challenge. In addition appropriate drilling fluid design to increase cooling ability is recommended.

Other key areas that affect drilling performance include availability of equipment – it is important to ensure minimal downtime during the drilling process. Availability of rig spares is key in this area. Adequately trained and experience personnel are a vital resource for geothermal drilling, the personnel must not only know how to operate equipment but also be able to analyse the parameters during the process. KenGen has undertaken training of drilling personnel in various forums including engineer trainings at the UNU-GTP in Iceland. In house training has also proven very beneficial as they are affordable and address areas identified by personnel themselves.