Proceedings, 6th African Rift Geothermal Conference
Addis Ababa, Ethiopia, 2nd – 4th November 2016

ANALYSIS OF NON-PRODUCTIVE TIME IN GEOTHERMAL DRILLING OPERATIONS - A CASE STUDY OF OLKARIA

Brenda Nyota and Moses M. Murigu
Kenya Electricity Generating Company
Olkaria, Naivasha
KENYA
BNyota@kengen.co.ke, mmurigu@kengen.co.ke

ABSTRACT

Geothermal well drilling is one of the most expensive activities in a geothermal project. Daily operational costs, such as the daily rig rate, make up a big part of drilling costs. The longer it takes to drill a well, the more expensive the well becomes. It is therefore important to optimize the time spent in drilling so as to optimize the cost of a well. To achieve this, an analysis of the non-productive time incurred while drilling a well is necessary so as to identify areas of improvement. This paper gives a review of the non-productive time incurred while drilling geothermal wells in the Olkaria field in Kenya with the view of improving the process and hence saving on costs.

1. INTRODUCTION

Non-productive time (NPT) does not have a standard definition. Organizations define NPT in a manner that suits their purpose. Rabia (2001) defines NPT as the time taken for any routine or abnormal operation that is carried out as a result of a failure or an event that causes the drilling operation to stop. The NPT for that particular event is given as the time taken to resume operations at the point right before the problem occurred. POOH so as to wait on a repair, and RIH after the repair are thus considered part of the NPT. Nabaei et. al. (1989) define NPT as the time in which drilling rate has stopped or as Cochener (2010) puts it, time the "bit is not turning to the right". Trip times, connection times and well surveys are included as NPT in this definition. In an issue of the drilling contractor (Linda Hsieh, 2010), NPT is described as anything that happens outside the original plan. This measure of NPT includes any time spent for an activity above the time which that activity was planned to take. For example, a necessary but unplanned for trip qualifies as NPT.

These definitions of NPT suit the objective to which they are used. Rabia's (2001) NPT is useful as a performance index, and a measure of how well the time used was utilized in useful activities. Nabaei's (1989) and Chochener's (2010) definition is measures of how much the time spend drilling a well is value adding i.e. how much time actually went into the actual creation of the well versus other supporting activities. This definition gives a lot of areas that can be reduced so as to improve on the drilling process and spend more time on well value adding activities, although it creates the impression that some necessary activities can be done away with. The drilling contractor (Linda Hsieh, 2010) uses NPT as a measure of what can be done better. A high NPT is thus viewed as a greater opportunity to improve processes and hence improve on drilling efficiency.

Drilling costs are proportional to the time it takes to drill the well. The rig day rate makes up for approximately 40-50% of the cost of a well (Schlumberger (2016), Kipsang (2014)). It is therefore very costly if this time is not spent gaining meters. Sometimes, and more often than not, the cost incurred during a downtime far exceeds the cost of having a contingency plan. For commonly occurring faults, it is necessary to analyze the feasibility and cost benefit of having a contingency plan in place, against the cost incurred when the fault does occur. The cost saving realized by this is usually immense. For example, for Chevron, the downtime incurred due to failure of, or while maintaining a BOP in deep-sea drilling operations lead to the purchase of a second BOP, at a cost of $25 million, so that one can be in use while the other is being repaired or maintained (Linda Hsieh, 2010). While the purchase of the extra BOP was initially costly, the benefits are tangible. At a spread rate of $1.2 million a day, it does not take long for the company to reap the benefits of having redundant BOP.

And this does not only apply to equipment redundancy. Investing in equipment that reduces time spent in an activity is also a way of cost saving. For example in tripping, any equipment that reduces the tripping time by half is worth investing in, considering the rig rate incurred while tripping. Investing in skilled maintenance personnel and proper maintenance practices is also a way in which cost saving can be achieved. An analysis of NPT is aimed at identifying areas of improvement, and showing how the said improvement leads to saving in the long run.

2. NPT ANALYSIS IN OLKARIA

The cost of a well is directly linked to the time it takes to drill a well. Prior to drilling, a well program is created that indicates the time each activity is planned to take. In Olkaria, a 3000m well is planned to take 55 days from spud in to completion. A breakdown of the activities and the time allocated to them is given in Table 1.

Table 1: Breakdown of the planned time allocated to drilling activities

Activity	**Time (Days)**	**Percentage time**
Drilling	32	58
WO cement	7	12
Tripping	7	12
Well completion	2	4
Casing	2	3
Reaming	1	3
WHA	1	2
DOC	1	2
Circulating	1	2
Breaking tubulus	1	1
Cementing	0.5	1
Deviation survey	0.3	0.5
Wiper trip	0.2	0.4
Total	**55**	**100**

As seen in table 1, drilling involves a number of activities. Actual drilling or “when the bit turns right”, takes about 40-60% of the time it takes to complete a well. The other time is spent on value adding activities, such as well casing and cementing, or on necessary but non-value adding activities such as tripping and circulating. At times, non-value adding activities outside the plan of the well such as fishing and stuck pipe operations, wait on repairs, etc., also occur. In planning for the time it takes to drill a well, drilling and other necessary activities are appropriated the time they are expected to take. When drilling the well, any activity that takes more time than it is actually planned to take is considered to have contributed to non-productive time. Also, any activity that occurs that was not in the plan is an NPT activity. NPT is calculated as time an activity takes above that which it is planned to take.

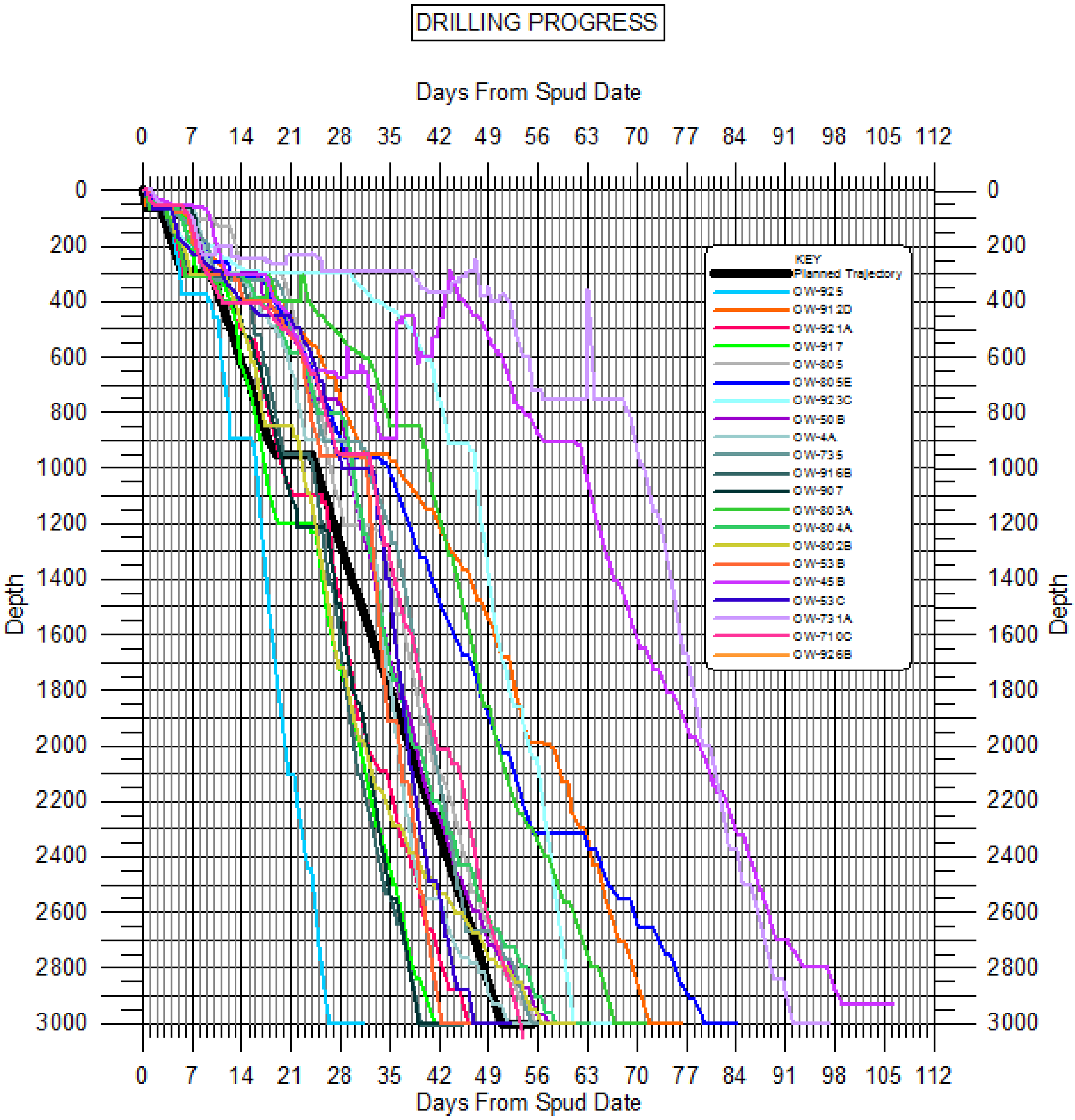

Figure 1: Actual time taken as compared to planned time

The cost of a well is directly related to the time it takes to drill a well. The longer it takes to drill a well, the more the well costs. This cost is passed on to the cost of the project. In severe cases, this may lead to surpassing the budget allocation. Also, wells are drilled within a given project time and it is important to ensure that the project is completed on time by minimizing the time it takes in each activity. This NPT analysis for wells drilled at the Olkaria Geothermal Field is done with the aim of avoiding this shortfalls, as well as for continuous improvement. The average time taken to complete a well so far in Olkaria is 61 days, against a plan of 55 days. A number of wells are drilled within the planned time, but some go beyond the planned time as shown in figure 1. To reduce this, activities that take more than the planned time are analyzed to see what could have been done differently. In addition, activities that take less than the planned time are noted as they serve as a point for further decreasing the time it takes to drill a well.

3. DATA ANALYSIS

The data analyzed here is from the Olkaria field in Kenya. The rigs used to drill the wells have the same set up and set up procedures and utilize the same equipment. Data is analyzed from the time the well is spud-in to the time a master valve is installed on the well. Wells analyzed are those that have been drilled to a depth of 3000m. For simplicity, wells drilled to 3500m were not used in the analysis. A sample of 20 wells taken from a total of 89 wells that have been drilled in Olkaria region are used in the analysis. The well samples taken are chosen so as to be representative of the number of days taken to drill the wells.

First, the time analysis data for the sample wells was obtained from the daily drilling report. The data was then grouped into classes of activities for each well. An average of the time taken for each activity for the twenty wells was then calculated. A difference between this average time and the planned time for each activity was then calculated to give the NPT activities. A comparison of the average time taken to the planned time allocated for each activity is given in Figure 2. Figure 3 shows the time taken for all activities other than drilling.

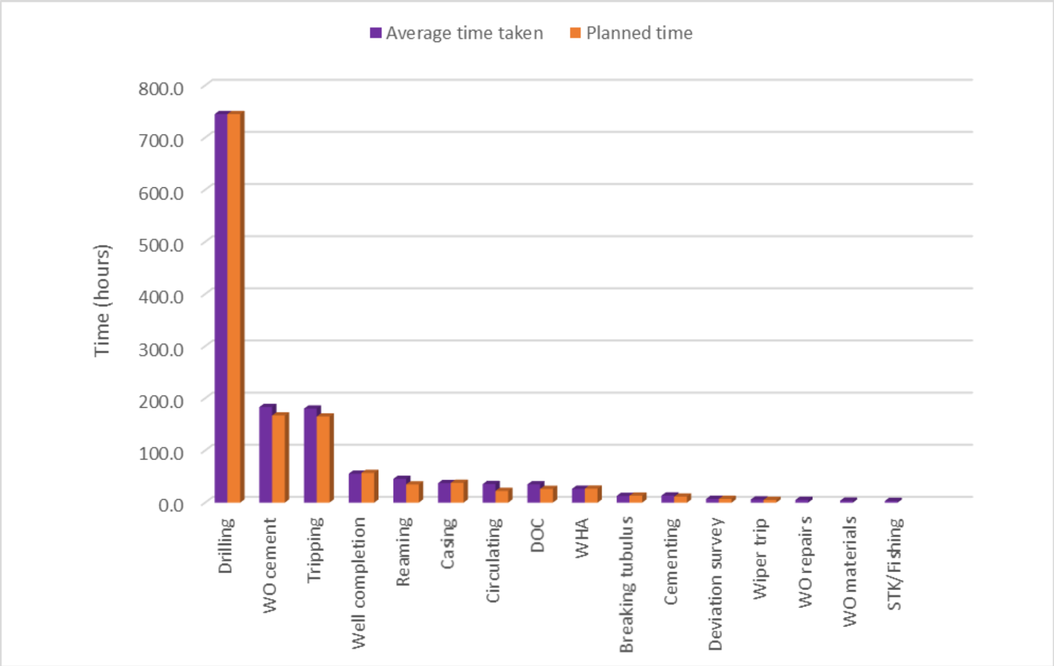

Figure 2: Comparison between the average time taken per well to the planned time for various activities

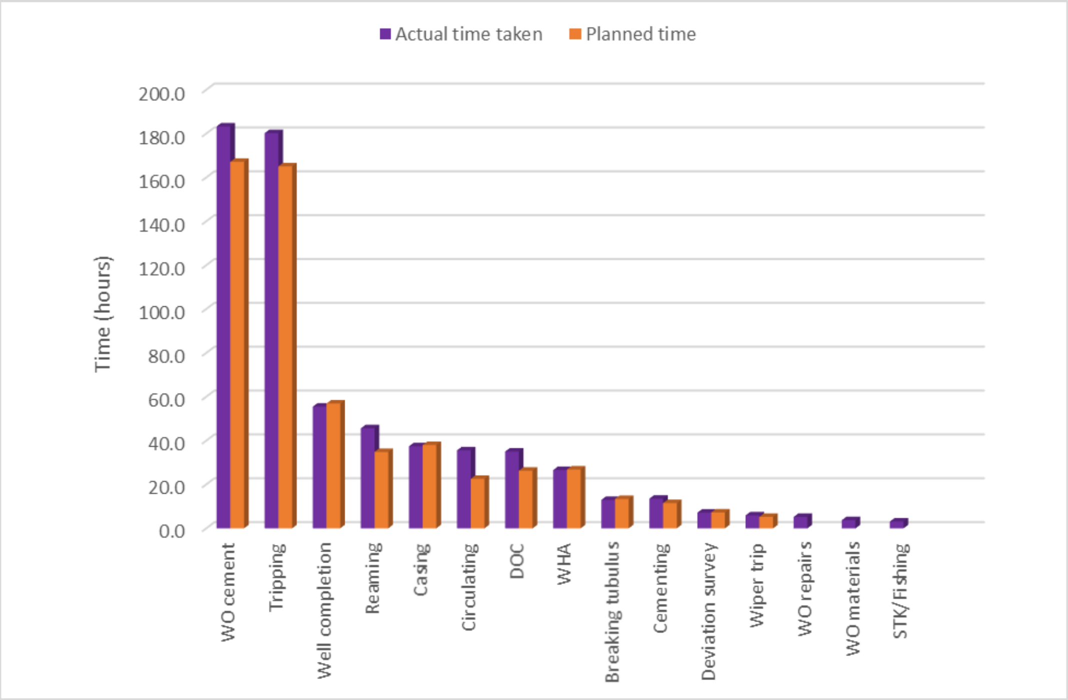

Figure 3: Comparison between the average time taken per well to the planned time for various activities (Drilling is not included for better scaling so as to highlight the other activities)

From the comparisons in Figures 2 and 3, any activity in which the value in the actual time taken bar graph exceeds that of the planned time has resulted in NPT. It should also be noted that there are some activities that take less time than that which is planned, showing that if the NPT activities are reduced, it is possible to look into more efficient drilling below the current planned time.

Figure 4 gives a breakdown of the percentage NPT for the various activities while figure 5 gives the percentage of non-productive time to productive time.

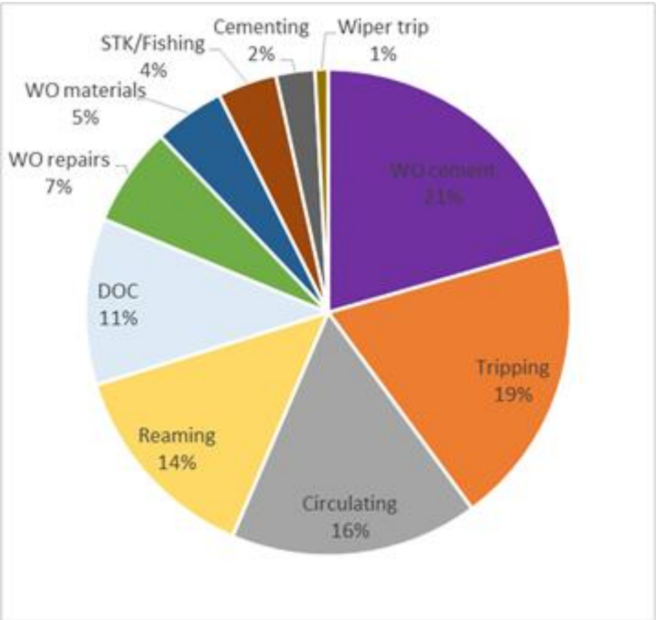

Figure 4: NPT breakdown

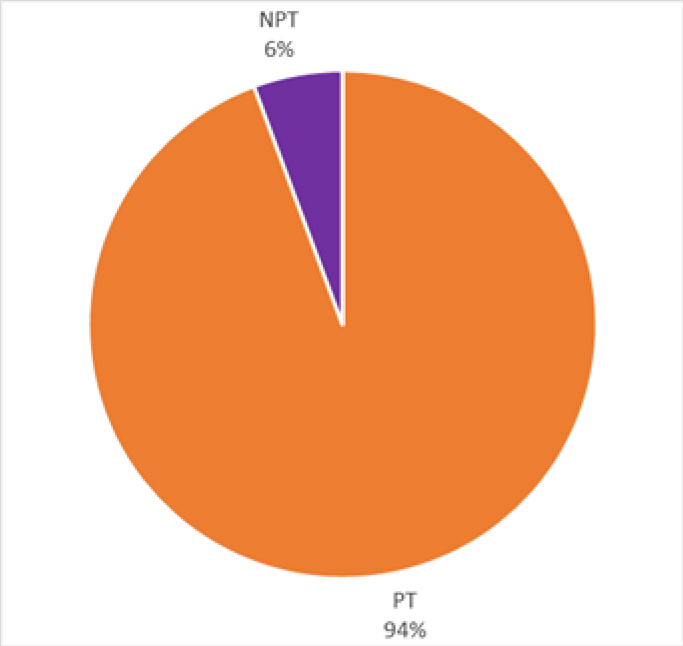

Figure 5: Productive time and non-productive time

4. DISCUSSION

4.1 Cementing operations

Cementing, waiting on cement and drilling out cement contributed to a total of 34% of the total NPT. In geothermal cementing, challenges encountered are mostly due to lost circulation, high temperatures, and the fracture gradient of the wellbore. Proper slurry designs and well calculated cementing jobs are therefore required every time.

When cementing areas where lost circulation is encountered, the cementing job must seal off the lost zone and provide a good bond between the formation and casing. If the lost circulation zone is not sealed off, multiple backfills have to be carried out, each taking a considerable amount of time to cement and wait on cement before the next operation. High temperatures encountered require the use of retarders in the cement, which slow down the cement setting, and increase the wait on cement time. The fracture gradient limits the volume of cement that can be pumped at a time, which may lead to several cementing jobs being carried out. In addition, cementing operations are carried out to heal collapsing formations. All these lead to an increased cementing operations time.

In all the above cases, the best way to reduce the NPT resulting from the cementing jobs is to ensure that the jobs are conducted as efficiently as possible. A constant review of individual cementing jobs is called for so as to come up with ways of reducing the time taken and hence the lost time. Currently in Olkaria, single stage cementing is in use. Using multi-stage cementing or inner string cementing should be considered as these methods reduce some of the challenges faced including long pumping times, high hydrostatic pressures leading to fracturing of weak formations, and the need to have several backfills. This will consequently reduce the time spent in cementing jobs.

4.2 Tripping

Tripping contributes to 19% of the NPT. Mainly, there are two ways in which tripping contributes to NPT: having high trip frequencies and having low trip rates. High frequency trip rates are as a result of many unplanned trips. For example, if a bit wears out after drilling less meters than it had been planned to drill, the trip necessary to change the bit is an NPT. Also tripping may be done so as to change the BHA after an unexpected wellbore deviation or so as pull the string to above casing shoe or to surface so as to deal with an unscheduled event such as a wait on repair or wait on material.

High trip frequencies are observed to be as a result of poor bit performance due to poor bit quality or having extremely hard and/or abrasive formations. A study on bit performance and optimization in Olkaria shows that with bit optimization, considerable cost saving can be achieved (Murigu & Bett, 2015). By using bits that give more meters while drilling, tripping frequencies can be reduced. Also, the equipment used in tripping should be very efficient so as to keep the trip time as low as possible.

4.3 Circulating

Circulating contributed to 16% of the NPT. One of the major challenges in geothermal drilling is lost circulation as drilling occurs through highly fractured zones. In dealing with lost circulation, the practice used is to first to use LCM material in an attempt to seal off the lost circulation zones. If this fails, drilling blind with water is used, while spotting a high viscous pill during connections. Aerated drilling is also used if the circulation returns are not recovered. Plugging the wellbore to heal lost circulation zones is used as a last resort, and especially so as it cannot be used in the main hole of the wellbore.

While drilling with lost circulation, it is important to constantly monitor the wellbore so as to note if it is filling up with cuttings. This is by circulating periodically while monitoring the wellbore for drag. An increased drag is an indication of a fill up of cuttings, and more circulation time is required to unload the wellbore. In addition to lost circulation, increased circulation time is incurred when quenching the wellbore. High geothermal temperatures encountered require that the well is quenched every time prior to POOH in order to prevent flow of steam to the surface. Before conducting a single shot deviation survey, the well has to be circulated and quenched to prevent stuck pipe and damage to the deviation survey tools. This adds to the circulation time.

Circulation problems can be considerably reduced by studying the wells history for surrounding wells that have been drilled and using this information to plan new wells accordingly so that troublesome zones are anticipated and dealt with before more problems are encountered. This is done by keeping better records on the well information while drilling, so that this can be referred to in drilling adjacent wells.

4.4 Reaming

The time spent while reaming is largely dependent on the BHA used. A balance has to be struck in the BHA selected as a very stiff BHA would present increased complexity in the event of stuck pipe while a less stiff BHA (fewer stabilizers) would require that some considerable amount of time is spent reaming the wellbore. Reaming reduces the chances of POOH casing should an obstruction be encountered while RIH casing and thus saving on time. Reaming while drilling by incorporating a reamer in the BHA is recommended as a way in which to reduce the time spent on reaming.

4.5 Wait on repairs

Wait on repairs contributed to 7% of the NPT. Payne (Linda Hsieh, 2010) cites the complexity of the modern day equipment as the biggest contributor to the NPT brought about by wait on repairs. Machinery and equipment have become more complex, requiring specialized personnel in their maintenance and repair. In addition, different vendors supply the different equipment that makes up the rig, and each has their own proprietary technology and specific software. Specialists are required to troubleshoot and repair each of the equipment. Training on one equipment does not necessarily mean competence in another. With such challenges, intensive crew training is necessary in order to ensure a comprehensive understanding of the working of equipment at the rig, its common failures and proper maintenance. This, coupled with rigorous maintenance policies and procedures would reduce the downtime caused by wait on repairs.

Equipment and parts redundancy is a measure that can be employed to reduce wait on repairs. For critical equipment that has high failure rate, a standby equipment can be purchased so that in case the equipment fails, the second can be used while repairs are going on.

4.6 Other NPT factors

The other factors contributed around 10% of the overall NPT. Some of the factors leading to the NPT are incident related. For example, cases of wait on materials or wait on water. For such, it is important that the incidences are investigated and measures put in place so as to ensure that they do not recur. Other factors are related to operations practices. For example, the best way to reduce time spent on stuck pipe and fishing is through preventing their occurrence through best drilling practices. A constant review of operation practices is recommended so as to bring these to a minimum.

5. CONCLUSION

NPT was found to be 6% of the time spent on a well, which amounts to 185,600 USD per well, and 16,518,400 USD for the 89 wells. Saving on this costs will go a long way in reducing the project costs. A review of the main causes that lead to this was done, and possible remedies to the problems given. Factors that contributed to the NPT were also noted to be incident and operation related. For these, it is recommended that constant monitoring of the operations with a view of process improvement is done so as to continually reduce them. In addition, one time incidences should be well investigated and measures put in place to ensure they do not recur. This paper focused on identifying that which did not go as planned and proposing solutions to this. Bit optimization, predictive planning based on previous well histories, better BHA design, comprehensive preventive maintenance schedules and provision of redundant equipment for those that have high failure rates are some of the ways that have been proposed to reduce NPT. Another area of study that is recommended is further reduction of even that which is in the plan, so that all activities take the optimum time possible.

REFERENCES

Cochener, J.: Quantifying Drilling Efficiency. (2010)

Kipsang, C.: Cost Model for Geothermal Wells, *Proceedings 5th African Rift geothermal Conference*. Arusha, (2014)

Hsieh L.: *http://www.drillingcontractor.org/rig-npt-the-ugly-truth-6795,* (2010)

Murigu, M. and Bett E.: Improving drilling performance with the use of PDC bits- A case study of Olkaria, *KenGen G2G Technical Seminar 2015*, (2015)

Nabaei M., Moazzeni A. and Moradinejad M.: Non-Productive Time (NPT) Analysis, New Opportunity in Drilling Operation Management, *1st National Conference on Novel Technologies in Oil and Gas Industries,* (1989)

Rabia H.: *Well engineering and construction*. Entrac Consulting, (2001)

Schlumberger.: *http://www.glossary.oilfield.slb.com/en/Terms/d/day_rate.aspx*, Schlumberger (2016)