UNITED NATIONS UNIVERSITY
UNU-GTP
Geothermal Training Programme

Orkustofnun, Grensasvegur 9,
IS-108 Reykjavik, Iceland

Reports 2019
Number 11

ASSESSMENT OF ROYALTIES ON COST OF GEOTHERMAL POWER GENERATION IN KENYA

Freda Nyambura Githuku
Kenya Electricity Generating Company, Ltd. – KenGen
KenGen Pension Plaza
P.O. Box 47936 – 00100, Nairobi
KENYA
fnyambura@kengen.co.ke

ABSTRACT

Kenya has been utilising geothermal resources for electricity generation since 1981. Over time, the utilisation has expanded and now includes recreation facilities and horticulture. The policies governing the utilisation of geothermal resources mentioned royalties (regular payments made by the lessee of a subsoil asset to the owner of the asset) but those were not specified until the Energy Act 2019 was enacted. The Olkaria I rehabilitation project was used to assess how sensitive the LCoE (levelized cost of electricity) would be to various variables, i.e. specific Capex, project lifetime, WACC (weighted average cost of capital), O & M (operation and maintenance) and the plant load factor. Using the FiT (feed in tariff), it was easy to see that the LCoE was most sensitive to the load factor. A major reduction of the load factor could lead to a LCoE above the FiT, meaning that the developer would suffer a double loss; the difference above the FiT and extra payments for the royalty.

1. INTRODUCTION

The East African Rift Valley runs from the Afar triple junction at the Gulf of Aden in the north to Mozambique in the south. Within the East African Rift lies the Rift Valley of Kenya where the Olkaria geothermal field is located (Ofwona, 2002). The Olkaria geothermal field is within the Hell's Gate National Park and the Olkaria I single flash geothermal power plant with three units of 15 MW each was the first power plant to be established in the Olkaria geothermal field. Commissioning of the units 1, 2 and 3 was done in 1981, 1982 and 1985, respectively (Ouma, 2008). The Olkaria I steam-field has nineteen production wells and three hot re-injection wells. The national power generating company KenGen owns Olkaria I, Olkaria II (105 MWe,) Olkaria IV (140 MWe), Olkaria I Additional Units (140 MWe) and wellhead units (83.3 MWe). These power plants are base load plants and are all located in the Olkaria geothermal area as shown in Figure 1.

Olkaria I has experienced normal wear and tear over the years it has been in operation with most of the equipment and the substation being obsolete, therefore spare parts are difficult to find. KenGen carried out an assessment and found it feasible to upgrade and rehabilitate all three units of the existing power plant, steam field and substation. The benefits of the rehabilitation would be an extended power plant life of 30 years, increased plant efficiency, increased power output and an improved plant availability of at least 95%. Therefore, with the rehabilitation project, the expected net power at design conditions

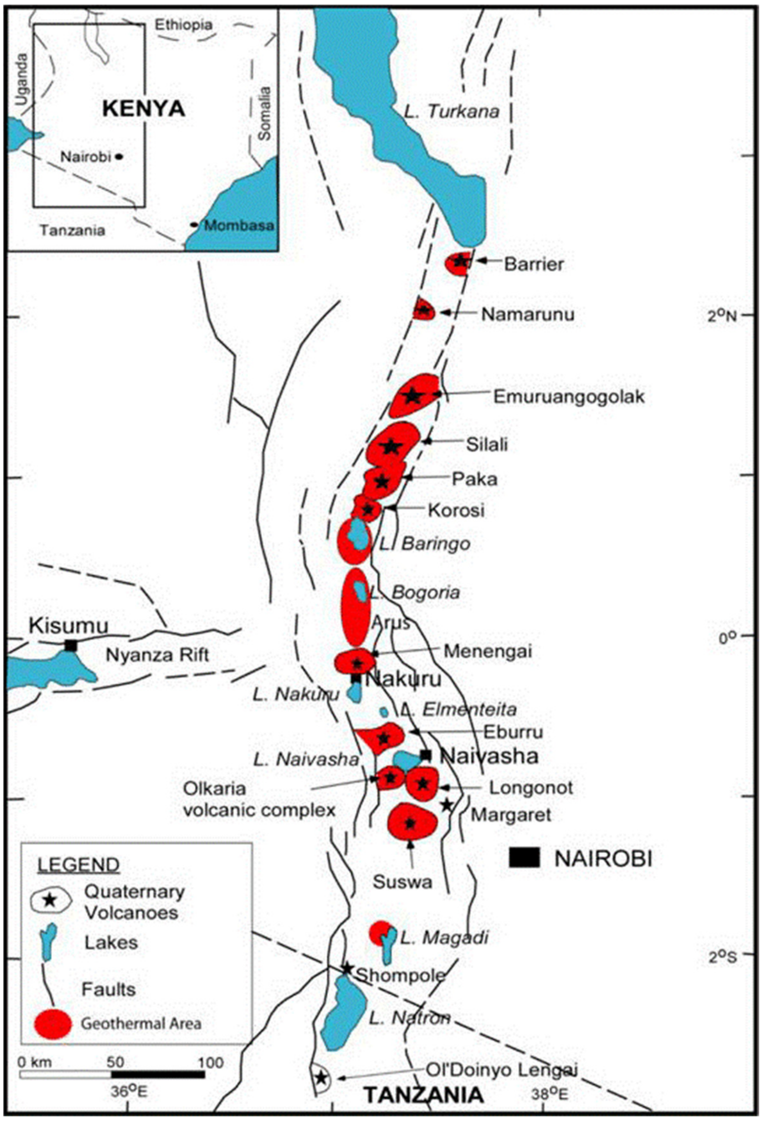

FIGURE 1: Geothermal areas in the Rift Valley of Kenya (Onacha, 2009)

should be at least 50.7 MWe, compared to a gross capacity of 45 MWe today. The old units are still generating power and during the rehabilitation the existing units should be stopped in a sequence to ensure minimum interruption to the units and power lines. That means that the units will be rehabilitated one at a time while the other old units continue to generate and each new unit will commence generation immediately after it is complete and commissioned. A sketch of how the plant will be rehabilitated is shown in Figure 2.

A royalty is a payment to the owner of an asset for the continued use of the owner's asset. The asset can be a franchise business, music, art, or natural resources with the corresponding royalties being franchise royalties, performance royalties, stock photography and natural resource royalties, respectively (Small Business, 2019). Natural resource royalties have different names in different industries. They are called resource rent in economics, mineral lease in mineral, natural gas and oil industries and stumpage in forestry (Royalty Exchange, 2019). Geothermal resources royalties being natural resources royalties would therefore be part of the natural resource rent that would come from geothermal power generation.

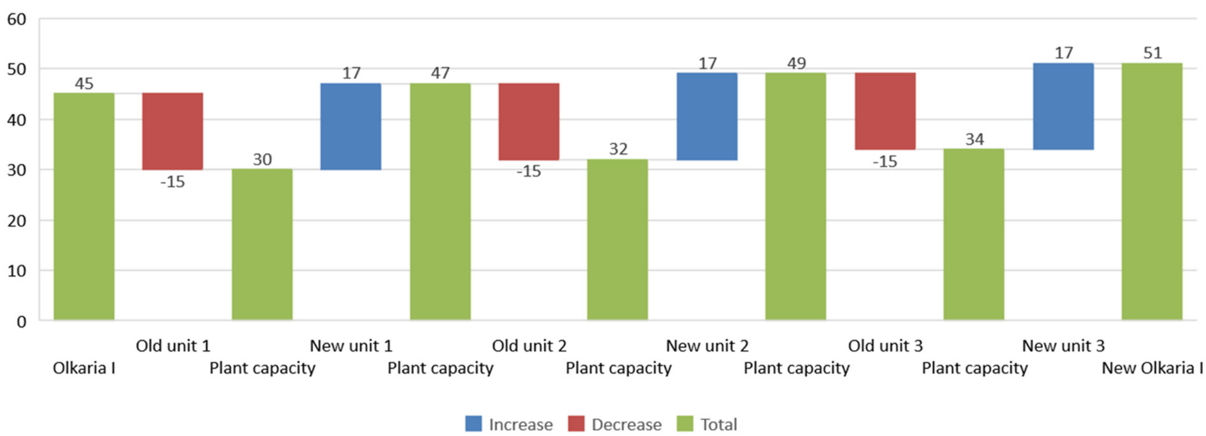

FIGURE 2: Olkaria I planned rehabilitation sequence showing how each of the units will be replaced with a new one and build up to the new capacity of 50.7 MW

Geothermal power plants are exploiting a natural resource by extracting heat from the geothermal aquifer. The contribution of the natural resource to the value creation is the resource rent which can be defined as the difference of the total cost of production, i.e. levelized cost of energy (LCoE) over the lifetime of the geothermal plant and the market price of the generated energy over the same period. For that reason, the owner of the natural resource is entitled to a part of the resource rent.

In Kenya, the Geothermal Resources Act from 1982 (Republic of Kenya, 1982) clearly stipulated in Clause 21 that the fees, rentals and royalties for use of geothermal resources would be determined by the minister. The Energy Act 2019 (Republic of Kenya, 2019) repealed the Geothermal Resources Act and introduced royalty rates. The royalties are based on the value of the geothermal resources extracted; 1% to not more than 2.5% during the first ten years of production and 2% to not more than 5% during each year, after the first ten year period. By introducing the geothermal royalty scheme the Kenyan government will be able to collect more revenue, which can be used to support other sectors of the economy. In addition, Kenya will be more aligned to the UN Sustainable Development Goals number 7 and 12 which are affordable and clean energy and responsible consumption and production, respectively.

While the royalties will for sure benefit the Kenyan economy at large, the question for developers is how the royalties will affect the competitiveness of their developed geothermal resources and how the royalties will affect the cost of capital for the development of geothermal resources. The research presented in this report aims to analyse this question with reference to the rehabilitation of Olkaria I.

2. REVIEW OF RELATED MATERIAL

2.1 Geothermal power development in Kenya

A consortium of companies started exploration for geothermal resources in Kenya in the year 1952. The consortium published a report that indicated that there is a high potential geothermal resource within the central part of the Kenya Rift Valley in the Olkaria area. The report proposed sites for two wells, which were drilled to a depth of 950 m and 1200 m, respectively, and reached measured downhole temperature of about 235°C. The wells did not discharge, which led to an abandonment of geothermal research and development until the 1970s.

Between 1971 and 1972, a geothermal exploration survey was carried out by the government of Kenya and the United Nations Development Program (UNDP) in the Olkaria, Eburru and Lake Bogoria geothermal prospects. The geothermal exploration involved geological mapping, hydrogeological surveys, gravity studies and infra-red imagery surveys (KPLC, 1992). This research concentrated on an area of 80 km^2 in the Olkaria geothermal field. The researchers recommended the drilling of four deep wells which were financed by the UNDP. The drilling of the wells started in 1973 and by 1976, six exploratory wells had been completed. The well data was used as input for a feasibility study whose focus was reservoir assessment, steam utilization for power generation, effluent disposal, by-product use and environmental impact of geothermal power development.

The feasibility study recommended the development of a 2 x 15 MWe power station, so more wells were drilled to provide enough steam for the generation of electricity. Olkaria I unit 1 with 15 MWe was the first power plant in the geothermal field that was commissioned in June 1981. Enough steam to generate another 15 MWe was substantiated by November 1982 and a total of 33 wells had been drilled in the Olkaria East Field by the end of 1984. These wells had a steam capacity to generate 45 MWe (Mangi, 2018). Olkaria I units 2 and 3, each with a capacity of 15 MWe, were commissioned in 1982 and 1985, respectively.

Over time, the concession area of 80 km^2 has been expanded and more power plants have been installed and also direct use of geothermal resources has been realised. The uses of geothermal resources within the Olkaria geothermal field are as follows (Table 1).

TABLE 1: Geothermal utilisation in Olkaria geothermal area

Geothermal utility	Description
Olkaria I power plant	Currently has capacity of 45 MWe (3 x 15 MWe). Units 1, 2 and 3 commissioned in 1981, 1982 and 1985, respectively. Plant to undergo rehabilitation.
Olkaria II power plant	Has capacity of 105 MWe (3 x 35 MWe). Units 1, 2 and 3 were commissioned in 2003, 2003 and 2010, respectively.
Olkaria IV power plant	Has capacity of 150 MWe (2 x 75 MWe). Was commissioned in 2014.
Olkaria I Additional Units power plant	Has capacity of 150 MWe (2 x 75 MWe). Was commissioned in 2015.
Wellhead power plants	Cumulative capacity of 83.5 MWe. Installation was accelerated between 2014 and 2015.
OrPower 4 power plant	Had capacity of 155 MWe at the end of 2018. Currently the only independent power producer within the Olkaria field.
Olkaria V power plant	The planned capacity is 165 MWe (2 x 82.5 MWe). Unit 1 was commissioned in 2019 and unit 2 is yet to be commissioned at the time of the writing of this paper.
Olkaria Geothermal Spa	Utilises brine from a well for a recreation centre within the Olkaria field.
Flower farming	Oserian greenhouses use 30 MWth from the Olkaria field.

In addition to Olkaria, the Kenya Rift Valley includes various geothermal areas that are subject to different geothermal resource development or studies as outlined in Table 2 below.

TABLE 2: Development stage of Kenya Rift Valley geothermal areas other than Olkaria

Geothermal area	Description
Eburru geothermal field	Six wells drilled between 1989 and 1991. Geophysical survey data and downhole data indicated that the field has a geothermal potential of 50–100 MWe. Only one of the wells discharged with an output of 2.4 MWe. KenGen commissioned a 2.4 MWe wellhead unit in this field in 2011.
Menengai geothermal field	Detailed surface exploration studies started in 2004 showing that the resource potential is 1,600 MWe. These studies resulted in siting and drilling of two exploration wells by the Geothermal Development Company (GDC). Eventually, more than 40 wells have been drilled with potential of about 162 MWe.
Arus – Baringo – Silali geothermal project	This project covers Arus-Bogoria, Korosi, Chepchuk, Paka and Silali geothermal prospects which have an estimated combined potential of 3,000 MWe. GDC has the mandate to develop the resource in phases and the phase I target is 100 MWe.
Suswa geothermal project	Detailed geoscientific studies carried out in 1992 and 1993 and showed that the field has a good potential for geothermal power development with an estimated potential of 750 MWe. Three wells have been sited on the main caldera floor.
Longonot geothermal area	Geological, geochemical and geophysical studies were carried out in 1988 and the results lead to the siting of two exploratory wells. African Geothermal International Limited (AGIL) has a license to explore and develop the area for a period of 30 years. This area has an estimated potential of 200 MWe.
Akiira geothermal prospect	Surface exploration studies were carried out in the 1990s and indicated a resource potential of more than 70 MWe. Two exploratory wells drilled in 2015 but they could not sustain discharge due to low pressure. Plans exist for more detailed surface exploration studies.
Barrier geothermal prospect	A reconnaissance survey was carried out in 1993, which reported the presence of surface manifestations indicating a hydrothermal system. In 2011, GDC carried out more surface studies and found subsurface temperatures of 281°C and an estimated resource potential of 750 MWe.

2.2 Resource rent

The OECD Glossary of Statistical Terms (2008) defines economic rent of a natural resource as "the value of capital service flows rendered by the natural resources, or their share in the gross operating surplus; its value is given by the value of extraction. Resource rent may be divided between depletion and return to natural capital." At the same time, resource rent of a natural resource can be defined as the difference between the revenue from extraction of a natural resource and the cost of extracting the resource with a return on investment for the extracting company (WTO, 2010). Resource rents vary based on location, market and cost of production.

Geothermal power plants exploit a natural resource by extracting heat from the geothermal aquifer. The contribution of the natural resource to the value creation is the resource rent which can be defined as the difference of the total cost of production, i.e. LCoE over the lifetime of the geothermal plant and the market price of the generated energy over the same period. For that reason, the owner of the natural resource is entitled to part of the resource rent. A simple illustration of the resource rent concept is shown in Figure 3.

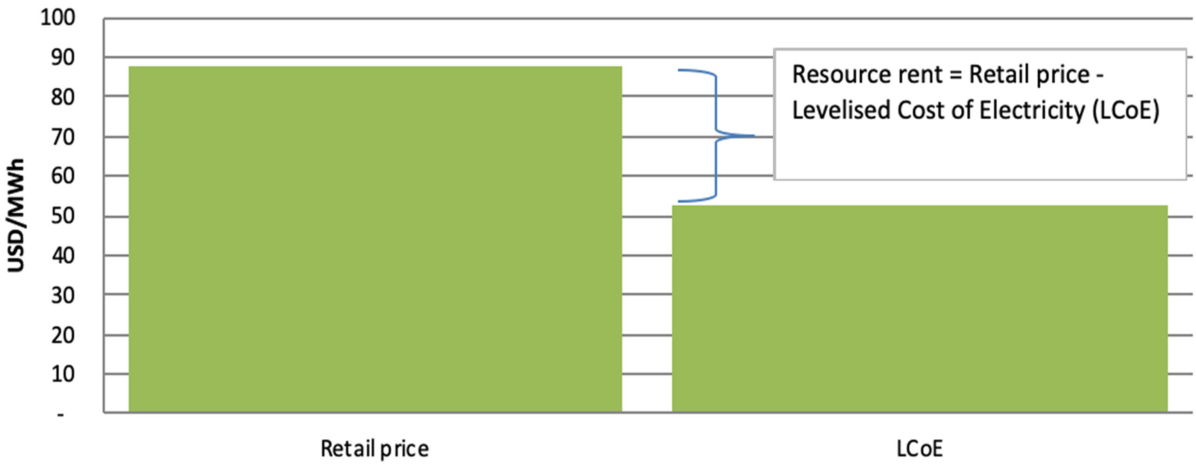

FIGURE 3: A simple illustration of the resource rent concept

2.3 Royalties

In the case of resource rent being generated it is considered fair that the user of the resource pays royalties to the resource owner. Since the resources have resource rents associated with them already, governments have been introducing some resource rent sharing scheme through the introduction of geothermal resources royalties. Royalties is the term often used to describe the regular payments made by the lessees of subsoil assets to the owners of the assets (OECD, 2008), as already mentioned.

Various economies have, or are in the process of, introducing royalties for their geothermal resources. Table 3 below summarises the geothermal royalties in selected jurisdictions.

Kenya, which is the focus of this research, has introduced the royalty payment in the Energy Act of 2019 (Republic of Kenya, 2019). In the Energy Act, clause 85 subsection 1 outlines the royalty payment for geothermal resources. Any holder of a license for geothermal resources shall pay a royalty on the value at the wellhead of the geothermal resources extracted of "not less than one per centum and not more than two and a half per centum of the value of geothermal energy produced from such resources during the first ten years of production under the licence; of not less than two per centum and not more than five per centum of the value of the geothermal energy produced from such resources during each year after such ten year period" (Republic of Kenya, 2019).

TABLE 3: Geothermal royalties in different jurisdictions

Jurisdiction	**Act**	**Royalty description**
Philippines	Renewable Energy Act of 2008	It is called "Government share" in the Act. The royalty is 1.5% of gross income of the generated power or any incidental income from the geothermal resources (Republic of the Philippines, 2008).
USA	Energy Policy Act of 2005; John Rishel Geothermal Steam Act Amendments of 2005	The Federal law states that "a royalty on electricity produced using geothermal resources other than direct use of geothermal resources that shall be – not less than 1% and not more than 2.5% of the gross proceeds from the sale of electricity produced from such resources during the first 10 years of production under the lease; and not less than 2% and not more than 5% of the gross proceeds from the sale of electricity produced from such resources during each year after such 10 year period" (U.S. Public Law, 2005).
Hawaii	Chapter 182; Reservation and disposition of government mineral rights	The payment of royalties to the state for the utilization of geothermal resources is fixed by the board of land and natural resources at a rate that encourages initial and continued production of resources. According to the Federal Law – Energy Policy Act of 2005, all royalties are paid to the Treasury of the United States with the exception of Alaska. Treasury remits 50% of the royalty to the state and 25% is remitted to the county that has the geothermal resources (State of Hawaii, 2005).
British Columbia	Geothermal royalty policy proposal by British Columbia Ministry of Energy Mines and Petroleum Resources	No royalties are in place but the proposed rates are ad valorem royalty of 3% after a 10 year royalty holiday OR ad valorem royalty initial rate of 0.25% that increases every 5 years by 0.75% to a maximum of 3% with no royalty holiday (British Columbia Ministry of Energy Mines and Petroleum Resources, 2018).
New Zealand		None

3. OPPORTUNITY COST OF OLD GEOTHERMAL WELLS

Geothermal power development relies on the available geothermal resource. This resource is mapped by geoscientific studies. Once the geoscientific studies are completed, the utilisation of the geothermal resource is determined based on the temperature of the resource. Drilling for the geothermal resource is consequently carried out. Over time, wells can decline in their output, based on how the power plant has been run over its lifetime relative to the capacity of the resource. Once a power plant has run its economic lifetime, the turbine and generator have most likely reduced in their efficiency and output. At the same time, the different wells may have a different output than they had right after drilling. The decision of what to do with the wells depends on the value that the wells can offer. The determination of the value means that the wells will have to undergo an evaluation so that if they are leased or connected to a new power plant the value of the wells would be incorporated in the pricing of the utilisation.

The valuation of assets in the power sector is very important for development, financing or operation of the organisations. The fact that power organisation assets do not trade as much poses a challenge in the valuation of the power generating assets. There are various valuation methods:

1. Income-based method
This method shows the quantity of the future costs and benefits from an asset to get a fair market value. This method advocates that the discounted future cash flows equals the value of a current asset. However, the future is unknown because regulations can change, technologies can advance, subsidies can be introduced and projected cash flows might change. Another challenge is determining the right discount rate that will show the asset's financing structure and risk profile.

2. Sales comparison method
This method compares the sales price of various assets. It is used where the comparable asset sales are large enough to show a meaningful comparison in order to get the fair market value.

3. Cost-based valuation method
This method determines the fair value of an asset assuming it is replaced and that an investor will not pay more for the asset than the cost of making a substitute asset. The challenge of this method is that the construction costs and depreciation can be difficult to measure because of change in prices over time.

In order to get a fair market value of an asset, it is advisable to use many methods so that the confidence level is high (Coyne et al., 2016).

Olkaria I is supplied by the Olkaria East Production Field (EPF) which has been exploited since 1981. Thirty-three wells have been drilled in the field of which nineteen production wells and three reinjection wells serve the Olkaria I power plant, one production and three reinjection wells serve the Olkaria II power plant, three reinjection wells serve the Olkaria IAU power plant, one is used for reservoir monitoring, one is earmarked for connection as a reinjection well in the future and two were plugged after the casings were damaged. The output of the wells has been monitored continuously. The monitoring provides the reservoir management with information on changes in the well outputs, so necessary remedial actions can be performed. Five production wells connected to the Olkaria I power plant have increased in mass flow. The Olkaria EPF declined initially while the drilling of make-up wells in the 1990s led to an upward trend. The output and monitoring of the Olkaria EPF has shown a marginal decline in the steam supply and an increase in the brine output from the wells. This is attributed to the natural decline of wells, causing reduced steam flow, and effects of infield brine reinjection that is now continuous (KenGen, 2016). Since the Olkaria I power plant has a steam demand of 450 t/h, the field's steam supply is sufficient.

The wells supplying the Olkaria I power plant are fully depreciated on the company books. The reality is though that the wells have an economic value that has been determined by the monitoring that has been going on. At the same time, the feasibility study showed that the wells are fit to run a rehabilitated power plant of 51 MWe for an economic life of 25 years. Therefore, these wells present an economic value of the price they would have realized if they were sold in the open market to another generator. This opportunity cost is shown in Figure 4.

The difference in the drilling costs in Figure 4 can be explained mostly by inflation. The purchasing power of 100 USD that was used in 1985 (assuming that all the wells were drilled in 1985) has the same buying power as 243 USD in August 2019 (U.S. Bureau of Labor Statistics, 2019). Therefore, Figure 4 shows the original cost at the time of drilling and the estimated original cost in 2019.

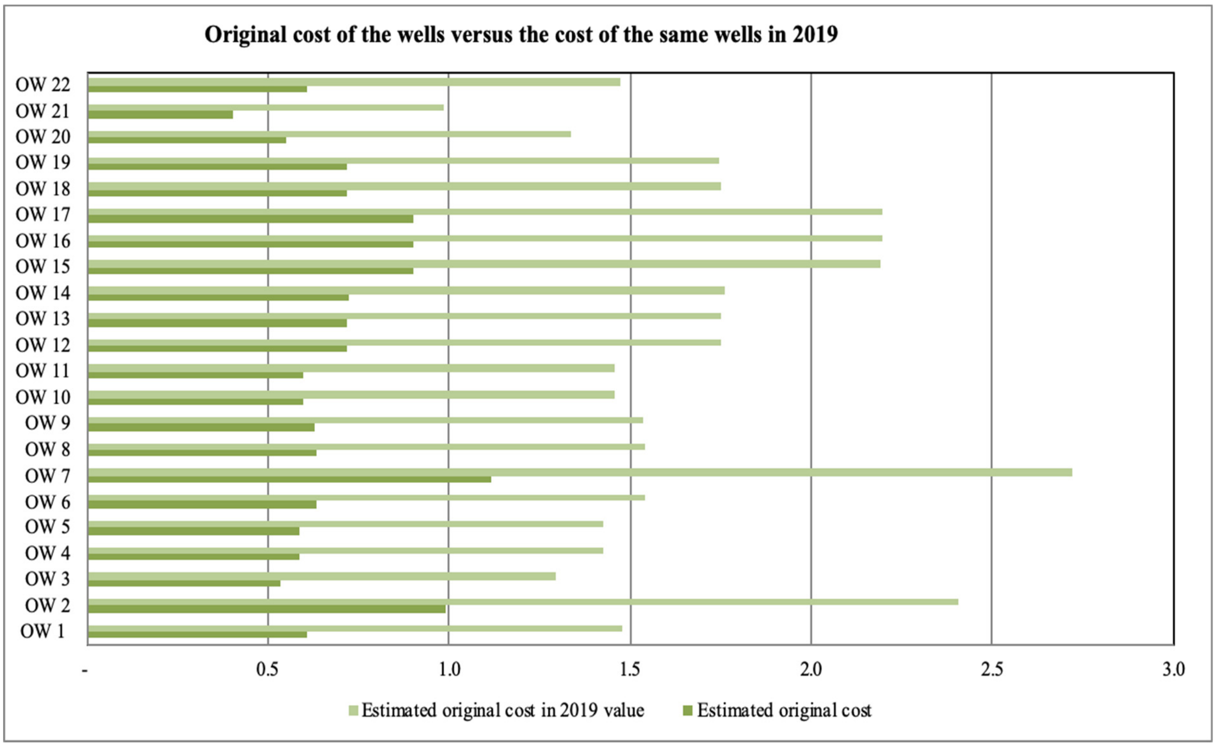

FIGURE 4: An illustration of the estimated original cost of the Olkaria I wells versus the estimated cost of drilling the same wells to the same depth today

4. DESCRIPTION OF WORK

A simple financial model to assess the impact of the introduced royalties in the geothermal power generation in Kenya was constructed. The model aimed first at estimating the Levelized Cost of Energy (LCoE) from which the resource rent was then calculated basing the electricity tariff on the Feed in Tariff (FiT). The assumption that the plant will be negotiated under the FiT led to the use of the FiT tariff. The sensitivity of key variables for the calculation of the LCoE and the resource rent was tabulated and the various results are presented in the results section.

The model considered the Olkaria I power plant which is one of the power plants within the Olkaria geothermal field and which is being rehabilitated. The data used is publicly available data. The economic model inputs are outlined below in Table 4.

TABLE 4: Economic model inputs

Various items important for the financial model	Used data
Plant capacity (MW)	51
Project lifetime (years)	25
Financing (MUSD)	169
Interest rate (debt)	1%
Weighted average cost of capital (WACC)	5.2%
Operation and maintenance (O & M) costs (% of project cost)	4%
Plant load factor	82%
Feed in Tariff (USD/MWh)	88

5. RESULTS

5.1 Financing

Funds necessary for this project were calculated first. The funds needed for the project were determined and broadly categorised into replacement value of the wells, lost revenue during construction, Capex, and Interest During Construction (IDC).

5.1.1 Replacement value of the wells

The wells supplying steam and being used for reinjection for this project are shallow wells that were drilled in the 1980s. Their total costs were equated to the value needed to drill them today using the available, efficient rig of KenGen. The estimated original cost was found to be 15.4 MUSD and the estimated replacement cost was calculated to be 68.4 MUSD.

5.1.2 Lost revenue during construction

The construction period was estimated to be two years starting in February 2020. Since the operating units will be rehabilitated one by one, there will be a loss of revenue during the construction period. With the assumption that the plant has a load factor of 50% because of its age, the estimated lost generation was calculated to be 131.6 GWh. This is equivalent to a lost revenue of 11.6 MUSD. This is illustrated in Figure 5.

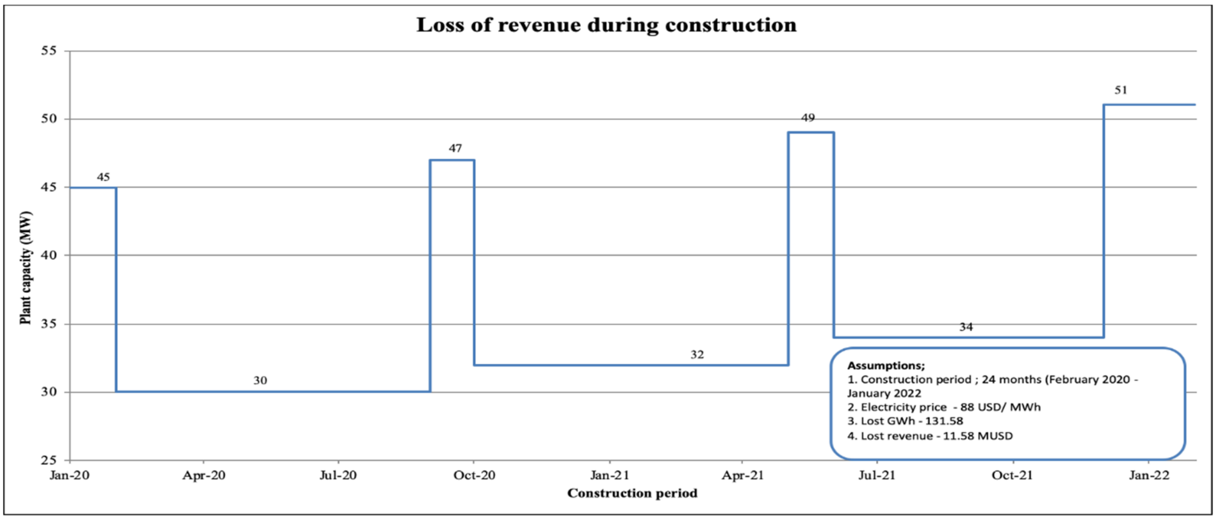

FIGURE 5: An illustration of the estimated loss of revenue during the construction period

5.1.3 Capex

A Capex value of 88.3 MUSD estimated during the feasibility study was used for the calculation. The breakdown of the amount is as illustrated in Table 5.

5.1.4 Interest During Construction (IDC)

The Interest During Construction (IDC) at 1% interest rate was calculated to be 0.95 MUSD.

5.1.5 Sources of Funds

The use of funds and sources of funds were balanced. Table 6 below lays out the project's financial structure matching the total cost or uses of those funds. The project received a loan equivalent to approximately 94.96 MUSD (JICA, 2018) which meant that to balance the sources and uses of funds

TABLE 5: CAPEX breakdown

Capex breakdown	Values
Development and financing	1
Equipment	31
Replacement well	11
Piping	7
Civil works	5
Instruments	4
Electrical	9
Insulation	0.06
Paint	0.2
Construction equipment and direct costs	2
Construction Management, Staff, Supervision	1
Freight	3
Engineering	3
Other Project Costs	9
Contingency	2
Total	**88.26**

the remainder would have to be from equity. The use of funds was 169.2 MUSD in total. Therefore, the equity portion was calculated to be 74.2 MUSD. The uses and sources of the funds that were considered are shown in Table 6.

TABLE 6: Sources and uses of funds

Uses	MUSD	Sources	MUSD
Repl. value wells	68.4	Debt	95.0
Lost generation value	11.6	Equity	74.2
Capex	88.3		
IDC	0.95		
Total uses:	**169.2**	**Total uses:**	**169.2**

5.2 Levelized Cost of Electricity (LCoE)

The LCoE for the project is calculated to be 52 USD/MWh. Various inputs that could form a basis for negotiation with the offtaker were tested for sensitivity, to show how the LCoE would be affected. The sensitivity of the result to the various variables is shown in Figure 6.

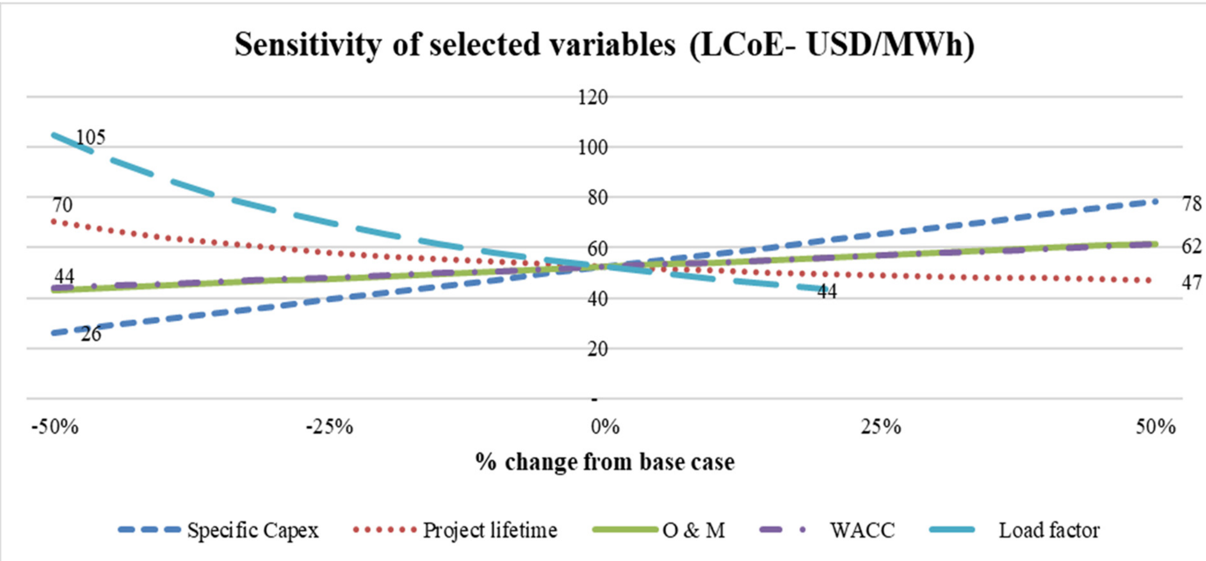

FIGURE 6: An illustration of the sensitivity of LCoE to selected variables from the base case (USD/MWh)

The conclusions that can be drawn from the results are:

a. The LCoE is very sensitive to the specific Capex because it oscillates between 26 and 78 USD/MWh if the Capex is reduced by 50% and increased by 50%, respectively.

b. The LCoE is less sensitive to the change of the project lifetime because it oscillates between 70 and 47 USD/MWh if the project lifetime is reduced by 50% and increased by 50%, respectively.

c. The LCoE of the project varies from 43 to 62 USD/MWh if the O & M costs are reduced by 50% and increased by 50%, respectively.

d. The WACC of the project is essential because the shareholders want the value of their investment to grow. The debt interest rate is already negotiated and thus the change in the WACC would most likely affect the equity hurdle rate. The LCoE varies between 44 and 62 USD/MWh if the WACC is reduced by 50% and increased by 50%, respectively.

e. The LCoE is highly dependent on the plant load factor as can be seen in Figure 6. The LCoE varies between 105 USD/MWh and 44 USD/MWh if the load factor is reduced by 50% and increased by about 20%, respectively. Since the project proposed load factor is at 82%, the sensitivity can only be increased by 18% because a plant load factor cannot be above 100%.

5.3 Royalty assessment

The geothermal royalty payment range for the Olkaria I rehabilitated power plant is estimated to be as shown in the Figure 7.

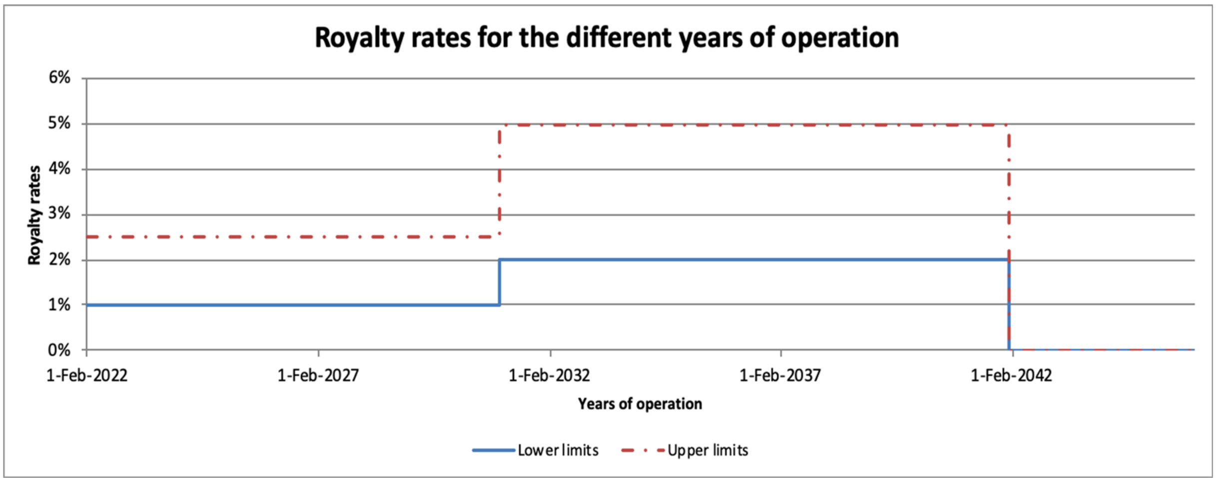

FIGURE 7: An illustration of royalty rates for the different years of operation of the rehabilitated Olkaria I power plant

The average of the royalty range percentage and the value of the percentage were calculated. The Net Present Value (NPV) of the royalty was calculated and the value sensitised to see how it varies if it is reduced by 90% or increased by 90% from the base case, that is, the average. The sensitivity of the NPV of the royalty was found to be as shown in Figure 8.

The royalty is apportioned to the national government, county government and local community in the ratio of 75%, 20% and 5%, respectively. The realised NPV of the royalty was apportioned in the given percentages and the portions are shown in Figure 9.

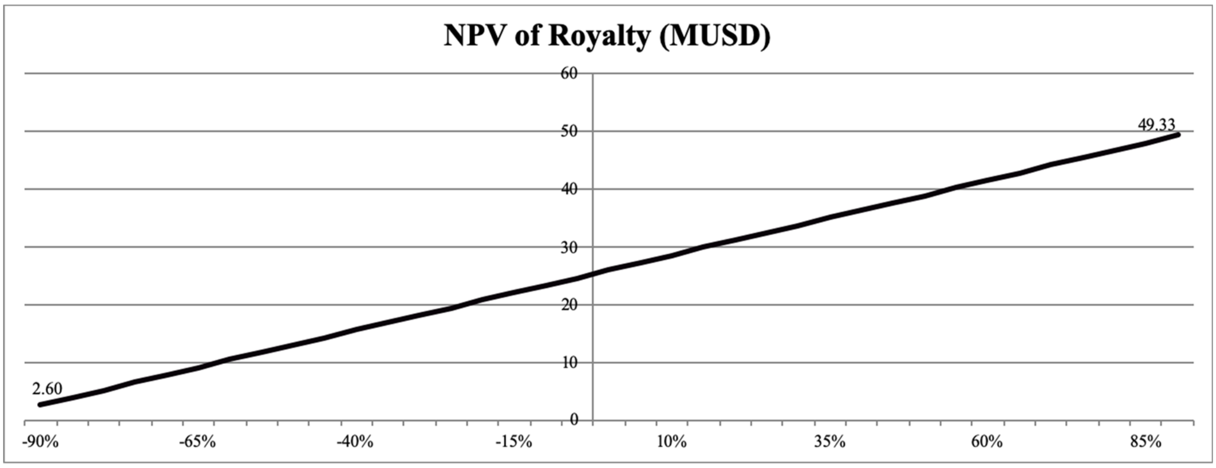

FIGURE 8: An illustration of the Net Present Value (NPV) of the royalty for the plant using Feed in Tariff (FiT) as the retail price of electricity

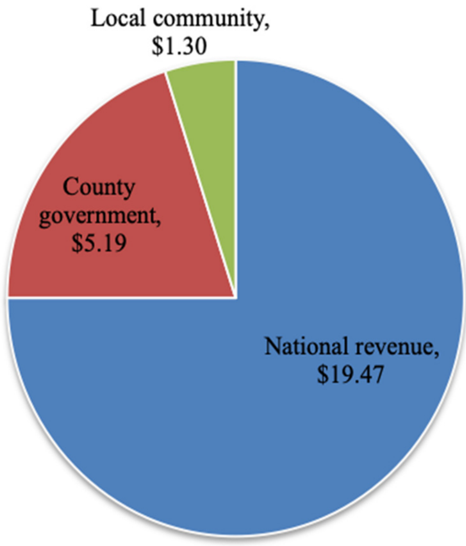

FIGURE 9: An illustration of the apportioning of the royalty (MUSD) (75% to the national revenue, 20% to the county government and 5% to the local community)

6. CONCLUSIONS

In theory, an operator who receives licence to exploit limited natural resource has an advantage over other producers not receiving the same. In energy production, this can be a licence to generate electricity from a feasible hydro or geothermal field. The cost of power is possibly lower than that of the competing generation, leading to the formation of resource rent as both producers are receiving market price or feed in tariffs for the electricity generated.

It is widely considered fair that receivers of such limited licence pay a part of the rent to the resource owner. In the Kenyan geothermal sector, this is done in form of royalties to the government. The royalty is a percentage of revenue, i.e., 1 - 2.5% for the first 10 years and 2 - 5% for the next 10 years. Therefore, the national government will be able to get revenue to support other developments in the country and all citizens will gain the benefits of natural resources that geothermal development has to offer.

Current and future geothermal resources developers in Kenya will have to sensitise their business models to accommodate the new policy direction. The Olkaria I rehabilitation project, which has been used here to calculate the resource rent and eventually the royalty, clearly shows that the LCoE is most sensitive to the load factor. The calculation also shows that the rehabilitation project is quite feasible with the given FiT. At the same time, because a developer can negotiate their electricity tariff away from the FiT policy, a developer would have to develop their business model in a way that they pay the royalty charges, add value to the shareholders, repay the loan and at the same time develop competitive geothermal products because the electricity ROE is regulated.

ACKNOWLEDGEMENTS

I appreciate KenGen management for giving me the opportunity to attend the UNU-GTP 2019 training. In addition, I appreciate my colleagues for supporting me throughout the training.

It is my pleasure to sincerely thank my supervisor Gunnar Tryggvasson for generously sharing his wealth of knowledge and guidance throughout. In addition, I am grateful to the UNU-GTP team lead by Mr. Lúdvík S. Georgsson, director, Mr. Ingimar G. Haraldsson, Ms. Málfrídur Ómarsdóttir, Mr. Markús A.G. Wilde, Ms. Thórhildur Ísberg and Dr. Vigdís Hardardóttir for their support in their respective capacities throughout the training period.

Finally, but not least, I am grateful to the Lord Almighty for protecting me throughout the training and I am glad for the support accorded to me by my family.

REFERENCES

British Columbia Ministry of Energy Mines and Petroleum Resources, 2018: *Intentions paper - geothermal royalty policy proposal.* British Columbia Ministry of Energy Mines and Petroleum Resources, Vancouver, BC, 9 pp.

Coyne, T., Gnaedig, G., Thibodeau, M. and Wroble, J., 2016: *Asset valuations in the power sector.* Sargent & Lundy consulting LLC, Chicago, IL, brief, 5 pp.

JICA, 2018: *Press releases.* Japan International Corporation Agency,
website: *www.jica.go.jp/english/news/press/2017/180316_01.html*

KenGen, 2016: *Steam status report.* Kenya Electricity Generating Company, Ltd. – KenGen, Kenya, internal report, 20 pp.

KPLC, 1992: *Geothermal exploration in Kenya.* Kenya Power and Lighting Co., Kenya, internal report.

Mangi, P., 2018: Geothermal development in Kenya – country update. *Proceedings of the 7th African Rift Geothermal Conference – ARGeo-7, Kigali, Rwanda,* 14 pp.

OECD, 2008: *OECD Glossary of statistical terms*. OECD Publishing, website:
doi.org/10.1787/9789264055087-en.

Ofwona, C.O., 2002: *A reservoir study of Olkaria East geothermal system, Kenya*. University of Iceland, MSc thesis, UNU-GTP, Iceland, report 1, 86 pp.

Onacha, S.A., Shalev, E., Malin, P., and Leary, P., 2009: Joint geophysical imaging of fluid-filled fracture zones in geothermal fields in the Kenya rift valley. *Geothermal Resources Council, Trans., 33,* 465-471.

Ouma, P.A., 2008: Geothermal exploration and development of the Olkaria geothermal field. *Presented at Short course III on exploration for geothermal resources, organised by UNU-GTP and KenGen, Lake Naivasha, Kenya,* 17 pp.

Republic of Kenya, 1982: *Geothermal resources act. Stipulations on fees, rentals and royalties for use of geothermal resources (valid till 2019).* Republic of Kenya, Nairobi, 38 pp.

Republic of Kenya, 2019: *Energy Act, 2019.* Republic of Kenya, Nairobi, 168 pp.

Republic of the Philippines, 2008: *Renewable energy act of 2008 - definition of terms.* Republic of the Philippines, Manila, 15 pp.

Royalty Exchange, 2019. *Energy Royalties.* Royalty Exchange, website: *www.royaltyexchange.com/blog/energy-royalties#sthash.6NEwtrcn.H4dDBSnG.dpbs*

Small Business, 2019: *What are royalties and how do they work.* Small Business, website: *www.thebalancesmb.com/what-are-royalties-how-they-work-4142673 – 14th August 2019.*

State of Hawaii, 2005: *Royalty payments*. State of Hawaii, website: *www.capitol.hawaii.gov/hrscurrent/Vol03_Ch0121-0200D/HRS0182/HRS_0182-0018.htm*

U.S. Bureau of Labor Statistics, 2019: *Inflation calculations.* U.S. Bureau of Labor Statistics, data tools, website: *www.bls.gov/data/inflation_calculator.htm.*

U.S. Public Law, 2005: *Energy policy act of 2005*. Government of USA, Washington DC, 551 pp.

WTO, 2010: *Natural resource subsidies*. World Trade Organization, website: *www.wto.org/english/res_e/publications_e/wtr10_yeo_e.htm*