Presented at SDG Short Course III on Exploration and Development of Geothermal Resources,
organized by UNU-GTP and KenGen, at Lake Bogoria and Lake Naivasha, Kenya, Nov. 7-27, 2018.

UNITED NATIONS UNIVERSITY
UNU-GTP
Geothermal Training Programme

KenGen

GEOTHERMAL EXPLORATION IN KENYA – STATUS REPORT AND UPDATES

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ABSTRACT

The world has 1.1 billion people without access to electricity. Out of this number, 600 million reside in sub-Saharan Africa. Most countries in this region have low electricity access rates of about 20%. With the high rate of population growth, this situation is expected to remain the same or worsen off, if corrective measures are not put in place. Closing the electricity gap in sub-Saharan Africa requires a multi-dimensional approach that will address the regions energy problem as a whole. Kenya is one of the countries that have put prudent measures in place to try and address electricity access challenges. In Kenya, electricity peak load consumption is expected to grow from 1,679 MW in 2016 to 2,225 MW by 2020. To address this growth in demand, Kenya has scaled up renewable energy resources' development with great focus on geothermal resources. Kenya is highly endowed with high temperature geothermal resources which are generally untapped. Geothermal resources are mainly geologically controlled. The resources are located within the Kenyan Rift Valley which forms part of the East Africa Rift System (EARS). The EARS is a 4,000 km long rift that spans from Afar triple junction in Djibouti to the north, to Beira in Mozambique to the south. Geothermal resources along the Kenyan Rift Valley are hosted within volcanic centers located along its axis. The centers extend from Barrier volcanic center in the north and end in Lake Magadi to the south. Some of these resources are well developed and in exploitation and utilization stage, whereas others are at various stages of exploration. The developed resources include Olkaria, Eburru and Menengai. Olkaria is in the generation and monitoring stage while Eburru and Menengai are in production drilling stage. Lake Magadi, Suswa, Longonot, Badlands, Arus-Bogoria, Lake Baringo, Korosi, Paka, Silali, Emuruangogolak, Namarunu and Barrier are at various stages of geothermal exploration. Geothermal exploration in Kenya began in 1952. By 1956, 2 wells, X1 and X2 had been drilled. The two wells yielded unsuccessful results which led to the abandoning of geothermal exploration in late 1950s and early 1960s. However, in 1972 after the oil crisis, geothermal exploration was accelerated. Further exploration culminated in production drilling and commissioning of the first geothermal power plant, Olkaria I, unit I in 1981. Currently, Kenya is ranked number nine worldwide as regards to geothermal energy production with an aggregate capacity of about 690 MWe. This power is generated by Olkaria I (45 MWe), Olkaria I unit IV&V (150 MWe), Olkaria II (105 MWe), Olkaria III (155 MWe), Olkaria IV (150 MWe), Wellhead generators (83.3 MWe), Oserian (4 MWe) and

Eburru wellhead (2.4 MWe). In 2009, the government formed Geothermal Development Company (GDC) as a special purpose vehicle (SPV) for geothermal resource development. Presently, GDC has drilled more than forty wells and realised 135 MWe in Menengai geothermal prospect. GDC has contracted three independent power producers (IPPs) namely Quantum East Africa Power Ltd., Orpower 22 Ltd., and Sosian Menengai Geothermal Power Ltd., to generate the first phase of 105 MWe. Each of the three IPPs will be entitled to generate 35 MWe. Similarly, three independent power producers namely Marine Power, Africa Geothermal International Ltd. (AGIL) and Olsuswa Energy Ltd. have been granted license for geothermal exploration in Akiira, Longonot and Barrier geothermal prospects, respectively.

Various financial partners have played a key role in the development of geothermal resources in the country. They include: Government finance, multilateral development banks, bilateral development agencies, special purposes finance (green funds), commercial banks and private equity. Some of the Direct Utilization steps made by Kenya include recreational purposes, fish farming, heating and fumigation of green houses, milk pasteurization and drying of crop harvests. Kenya has also faced a fair share of challenges in geothermal development especially during the early stages of development. These include; Legislative and policy challenges, human capacity challenges, environmental and socio-economic challenges and financial challenges among others. Nevertheless, measures have been put in place to address these challenges. The Kenyan government is focusing on having 2,500 MWe geothermal contribution in the country's energy mix by 2025.

1. INTRODUCTION

Kenya's electricity peak load demand is projected to grow from 1,679MW in 2016 to 2,225MW by 2020 (Ministry of Energy, 2018). During this period, the installed capacity is projected to increase from 2,333 to 5,122 MWe. Of this, 917 MWe will be from hydropower, 1,565 MWe from geothermal, 506 MWe from wind, 185 MWe from biomass, 442 MWe from solar, 560 MWe from thermal, 327 MWe from coal and 400 MWe from import. The reserve margin is projected to range between 19 and 45%. The surplus capacity will be available for regional power trade. This will be facilitated by the interconnection under the East Africa Power Pool. The interconnected system installed capacity as per end October 2018 was 2.720 GW. Out of this, geothermal contributes about 690 MWe, hydropower 823 MWe, thermal has a total of 776 MWe and wind has 325.5 MWe, solar has 50 MWe while cogeneration contributes 28MWe. Kenya also has an off-grid system in areas away from the interconnected system. As at September 2018, the off-grid installed system was 27.52 MW and consisted of diesel, solar and wind power plants. The off-grid thermal is at 26.33 MWe, wind is at 0.5550 MWe, while solar is 0.64 MWe. The power percentage rate as per consumption is 47% geothermal, 39% hydropower, 13% thermal and 0.4 % wind. With the fluctuating climatic conditions, the Government of Kenya shifted focus to the development of more renewable modes of generation beginning 1970s. That has seen more efforts being employed in harnessing of geothermal, wind and lately solar power. Table 1 gives a summary of the current installed capacity by mode of generation, projects onto which funds have been committed and those under construction, while Table 2 shows the projects under construction and those onto which funds have been committed but not yet under construction.

Power generation is anchored on an efficient and effective transmission and distribution network system. In Kenya, the Kenya Power and Lighting Company (KPLC) is tasked with transmission and distribution of the generated power to customers. KPLC has launched various projects aimed at attaining efficient and effective power distribution (KPLC, 2017). These include; the Last Mile Connectivity Project (LMCP) aimed at increasing electricity access to Kenyans especially the low income group, the Kenya

Electricity Modernisation Project (KEMP) aimed at enhancing the electricity network in readiness for the anticipated 5000+ MW generation by 2030, and the Global Partnership on Output Based Aid (GPOBA) electrification project.

TABLE 1: Present and planned electricity production

	Geothermal		**Fossil fuels**		**Hydro**		**Other renewables**		**Total**	
	C[1] MWe	GP[2] GWh/yr	C MWe	GP GWh/yr	C MWe	GP GWh/yr	C MWe	GP GWh/yr	C MWe	GP GWh/yr
In operation	690	6,044	776	6,798	823	7,209	406	3,557	2,695	23,608
Under construction	365	3,197	-	-	-	-	-	-	365	3,197
Funds committed but not yet under construction	185	1,620.60	1,000	8,760	-	-	120	1,051	1,305	11,432
Estimated total projected use by 2020	2,765	24,221	3,753	32,876	1,310	11,477	679	5,948	8,507	74,523

1: Capacity; 2: Gross production (assuming 100% availability).

TABLE 2: A breakdown of projects under construction and those which funds have been committed

Project	**Mode of generation**	**Status**	**Company**	**Capacity**	
				C[1] MWe	GP[2] GWh/yr
Baringo-Silali	Geothermal	Under construction	GDC	100	876
Menengai	Geothermal	Under construction	GDC	100	876
Olkaria V	Geothermal	Under construction	KenGen	165	1,445
			TOTAL	**365**	**3,197**
Lamu coal project	Fossil fuel	Funds committed	Centum Investment / Gulf Energy	1,000	8,760
Menu	Wind	Funds committed	KenGen	80	701
Gitaru	Solar	Funds committed	KenGen	40	350
Olkaria 1AU6	Geothermal	Funds committed	KenGen	70	613
Wellheads	Geothermal	Funds committed	KenGen	108	946
Olkaria 1 upgrade	Geothermal	Funds committed	KenGen	7	61
			TOTAL	**1,305**	**11,432**

1: Capacity; 2: Gross production.

GPOBA project is a partnership between World Bank and KPLC aimed at preventing commercial losses by reducing cases of electricity theft while providing convenient services to customers through prepaid metering. It is also noteworthy to mention the Boresha Umeme Network Upgrade Project. Under this project, networks serving major customers as well as areas with repeated poor supply quality issues are given a priority in a focused and thorough maintenance effort that pools resources to one locality. The last project is the Street Lighting Project, rolled out on 15th January, 2016. The project aims to cover 52 towns and trading centres in all the 47 counties.

Moreover, KPLC is undertaking several Network Expansion and Maintenance Programmes (KPLC, 2017). Three programmes are scheduled under this. They include the Underground Cabling Project, Live Line Maintenance Programme and Rapid Response Team. The Underground Cabling Project is aimed at improving electricity supply in Nairobi through refurbishment of the existing network and building of additional lines and new substations. The Live Line Maintenance Programme will see the maintenance of electricity distribution network without switching off. This will address revenue losses and customer inconveniences. The Rapid Response Team was created in 2016 to deal with electric power emergencies. The team uses motorbike transport to reduce emergency response time.

Geothermal Power plants serve as base loads due to their high availability factor as well as lowest unit cost (Ondraczek, 2014). This is well supported by the current Olkaria geothermal power plants which operate as base loads with more than 95% availability. Hence, geothermal energy stands to play a major role in realization of Kenya's future energy targets stipulated in vision 2030. The government targets a total of 5,000 MWe power generation from geothermal sources by 2030 (Micale et al., 2015).

The Kenya Rift Valley is endowed with high potential high temperature geothermal resources that remains largely untapped. The Kenyan Rift forms part of the larger East Africa Rift System (EARS). EARS transects East and Central Africa spanning from Afar triple junction to the North and fading in Beira, Mozambique to the south. Kenya's geothermal resources are hosted within volcanic centers which are located with the axial of the Kenyan Rift Valley. These volcanic centers span from Barrier volcanic center in the north and end with Lake Magadi in the south (Figure 1). The Olkaria resource is well developed and in generation and monitoring stage of geothermal exploration. Eburru and Menengai are in production drilling stage even though Eburru already has a wellhead unit already constructed for generation. Lake Magadi, Suswa, Longonot, Badlands, Arus-Bogoria, Lake Baringo, Korosi, Paka, Silali, Emuruangogolak, Namarunu and Barrier are at various stages of geothermal exploration. Geothermal studies carried out within the Kenyan Rift indicate a potential in excess of 10,000 MW of geothermal resource.

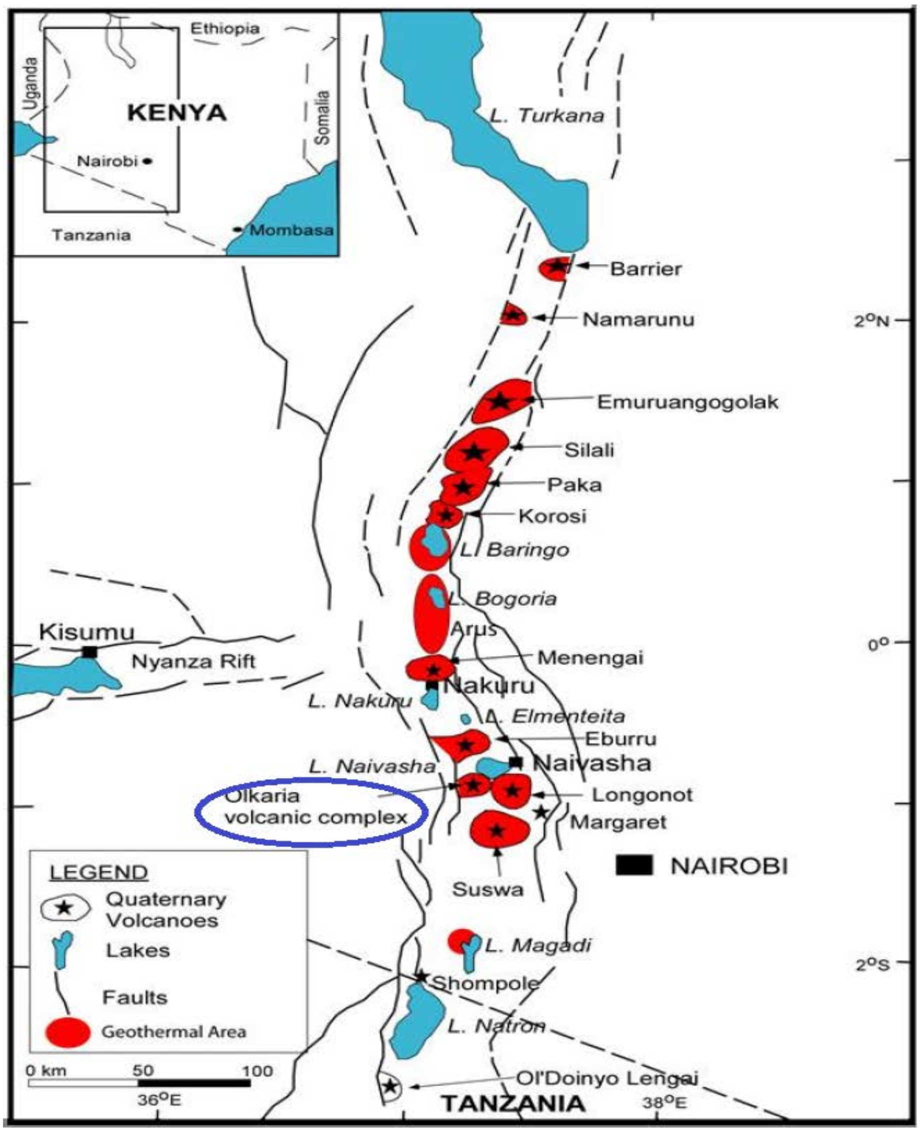

FIGURE 1: Location of geothermal fields and prospects along the axial region of Kenyan rift

2. GEOTHERMAL DEVELOPMENT IN KENYA

The history of geothermal development in Kenya has been well documented in KPLC (1992). Geothermal development in Kenya dates back to 1952. The initial studies were conducted by a consortium of several companies. These included; East African Power and Lighting Company Ltd (EAPL), Power Securities Corporations Ltd, Associated Electrical Industries Export Ltd, and Babock and Wilcox Ltd. The study resulted into the siting of two wells X1 and X2 in 1956 within Olkaria. The two wells, drilled to a total depth of 950 m and 1200 m, respectively recorded a measured downhole temperature of about 235°C. Unfortunately, the wells were not able to discharge. This led to the abandoning of geothermal research and development until 1970s. After the 1970 oil crisis, focus shifted back to development of renewable to curb the world energy security. From 1971 to 1972, a joint geothermal exploration work between the Government of Kenya and the United Nations Development Program (UNDP) was carried out from Olkaria to Lake Bogoria and Eburru geothermal prospects. This was an extensive work which included geological mapping, hydrogeological surveys, gravity studies and infra-red imagery surveys. The research narrowed down to an area of about 80 km^2 in Olkaria geothermal field. This area was found to be the most prospective.

From the research data, four wells were sited and drilling began in 1973 by funds from UNDP. The drilling was carried out by the East Africa Community owned East Africa Power Lighting Company's rig. By 1976, six exploratory wells had been drilled, with the deepest being 2200 m. Data from the drilled wells provided more platform for further analysis and feasibility studies. A feasibility study was done by SWESCO, Stockholm and VRKIR Consulting Group Ltd.

The study focused on reservoir assessment, steam utilization for power generation, effluent disposal, by product use and environmental impact of the geothermal power development. The feasibility study recommended the development of 2*15 MWe power plant. UNDP pulled out after the feasibility study. Active drilling continued from 1977 under the supervision of Geothermal Energy New Zealand (GENZL).

Kenya Power Company (KPC), formed after the dissolution of the East Africa Community in 1977 was tasked with the development of geothermal resources in the country. KPC continued with the drilling and in June 1981, the first 15 MWe of geothermal power plant was commissioned. By November 1982, the drilling had gathered enough steam to generate additional 15 MWe. This was commissioned in November 1982. By the end of 1984, a total of 33 wells had been drilled in the Olkaria East field with steam capacity enough to generate a total of 45MWe from this field. This resulted in the commissioning of the third 15 MWe generating unit in March 1985. Since then, exploration work has continued in the Olkaria geothermal field. The concession area has since been expanded and a total of about 302 wells have been drilled to date in the larger Olkaria geothermal field. In 1990's, the field was divided into seven sectors for ease of management and exploitation. A summarized breakdown of the geothermal power plants' development in Olkaria geothermal field is as explained below.

2.1 Olkaria geothermal field

Olkaria geothermal field is its production and monitoring stage. It is also the most explored with exploration period spanning over 65 years. Currently, about 690 MWe is being generated from the field. Additionally, 30 MWt from the Olkaria field is being utilized for flower farming and recreational purposes in the Oserian green houses and Olkaria geothermal spa, respectively. Olkaria geothermal resource has a proven resource potential of about 1200 MWe. For the purpose of managing rapid expansion of geothermal power development, the field is divided into seven segments (Figure 2). Olkaria geothermal field stands out as the pioneer field in which wellhead generators have successfully been installed and operated. There is also a natural spa constructed by KenGen that taps from this field. The highest single producing well in Africa, well OW-921A is located in this field with a capacity of 30 MWe.

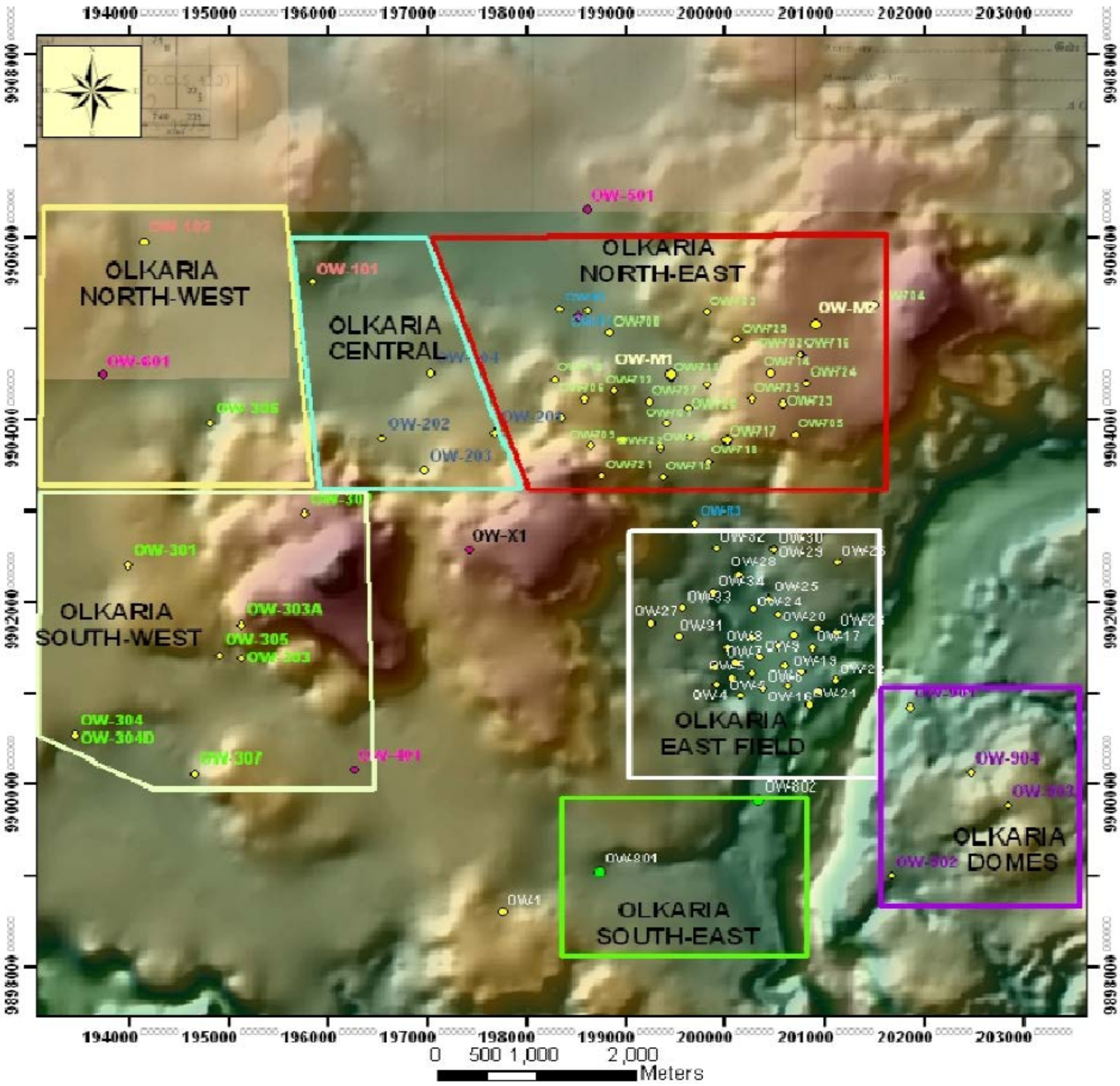

FIGURE 2: The seven segments of Olkaria geothermal field

2.1.1 Olkaria I power station

Olkaria 1 power plant is the oldest geothermal power plant in Kenya. The plant taps its steam from the Olkaria East sector and generates 45 MWe (Figure 3). It has three units each generating 15 MWe. The three units utilizes steam from 22 wells. The plant has 33 wells assigned to it. One of the 33 wells is used for re-injection, two have been retired while the rest serve as standby wells. Currently, the field has extra steam capacity capable of generating 25 MWe. Plans are underway to upgrade the old plant and increase its capacity to tap into this steam. Olkaria 1 power plant is owned and operated by KenGen.

2.1.2 Olkaria II power station

After commissioning of the third unit of Olkaria 1 power plant, drilling expanded beyond the Olkaria East sector beginning 1986. By 1992, more than 30 wells had been drilled in Olkaria North East sector. Reservoir testing indicated a potential capacity of about 105 MWe from the steam from these wells. There was a delay in the development of power plant as the political agitation and inflation that rocked the country from 1990 to 1997 dissuaded financiers from investing into the country. However, in 1999, finances were sourced for this development. This resulted in the commissioning of the first 70 MWe two units of Olkaria II in 2003. The third unit generating 35 MWe was commissioned in May 2010 bringing the total Olkaria II power plant installed capacity to 105 MWe (Figure 4). 22 of the 30 drilled wells supply steam to the three power generating units. Olkaria II is owned and operated by KenGen.

FIGURE 3: A view of Olkaria 1 Power plant located in the Olkaria East Production Field

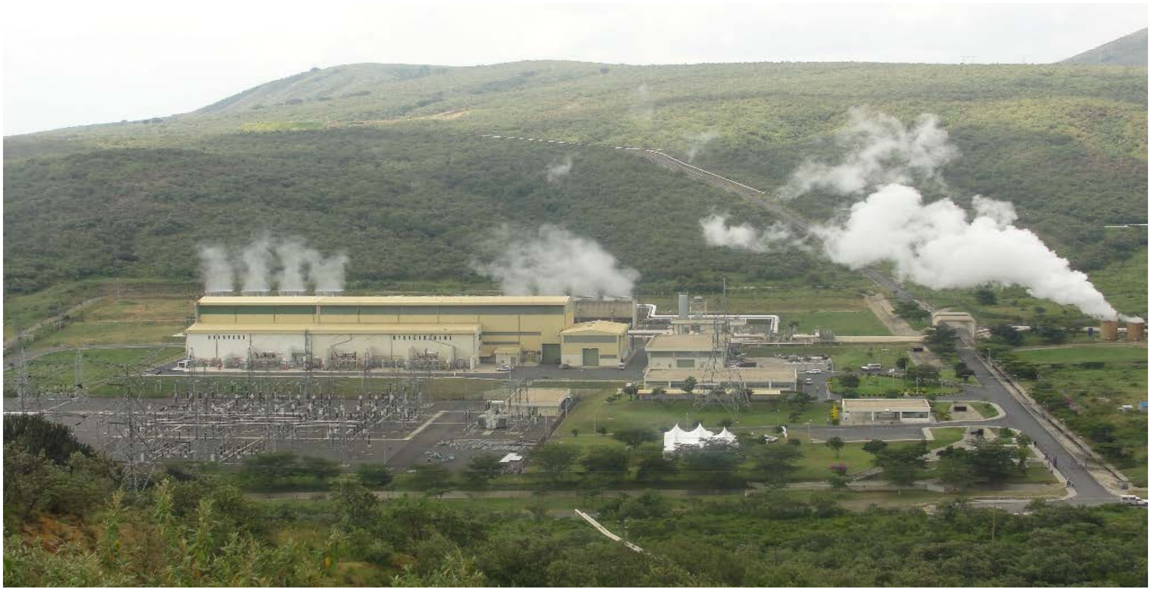

FIGURE 4: View of Olkaria II power station

2.1.3 Olkaria III power station

Keen on improving accessibility rates and security of power in the country, the government of Kenya initiated reforms in the Energy sector in 1996. The main agenda was to decentralise Kenya's power sector. Part of these reforms was the opening up of the power generation to Independent Power Producers. In 1997, ORMAT International was licensed by the Kenya Government to explore and generate power from the Olkaria Northwest field. This was referred to as Olkaria III. In August 2000, ORMAT, through its local subsidiary OrPower 4, commissioned 8 MWe that was later increased to 12 MWe from a combined binary cycle pilot plant. This was the first geothermal plant to use binary technology. Further drilling by Orpower saw then commission an additional 35 MWe in 2009, 36 MWe in 2013, 26 MWe in 2014 and 29.6 MWe in 2016 bringing the total installed capacity to 139.6 MWe.

In early 2018, they further commissioned 15 MWe additional power. Currently, Olkaria III has a total installed capacity of 155 MWe. The power plant draws its steam from the Northwest sector.

2.1.4 The Olkaria 300 MWe Project: Olkaria IV and Olkaria 1 AU

With the country's vision 2030 power targets, more focus was put on geothermal development. This saw rapid expansion in drilling of more geothermal wells the later culminated into the injection of the Olkaria 300 MWe project into the national grid by 2014. The Olkaria 300 MWe project comprises the Olkaria IV and the Olkaria I additional units 4 and 5. Each of the two power plants has an installed capacity of 150 MWe. Olkaria I units 4&5 draws steam from Olkaria East and partly Northeast sectors. The 150 MWe Olkaria IV (Figure 5) draws its steam from the Domes sector. In 1999, KenGen, basing on surface exploration work carried, drilled three exploratory wells in the Domes sector of Olkaria field. The data analysis from the drilled wells indicated resource potential in this field. Appraisal drilling was carried out by funds provided by the government of Kenya. The results were promising and this led to the drilling of seven production wells in 2007. The drilling contract was awarded to the Chinese Great Wall Drilling Company (GWDC). In 2006, the government of Kenya funded appraisal drilling in the Domes field. In 2007, the government signed a six production wells' drilling contract with the Chinese owned Great Wall Drilling Company (GWDC). With improved technology, deeper and directional wells proved to tap more resources.

FIGURE 5: Olkaria IV power plant located in Domes area

In 2009, the first optimization study done by WestJec proved a resource potential of more than 150 MWe in Domes sector and 150 MWe in both East and Northeast sectors. Construction works on the each of the 150 MWe power project for Olkaria I units 4&5 and, Olkaria IV began in March 2012 and 23rd July 2012, respectively. Olkaria IV power plant was commissioned on 17th October 2014, while Olkaria I, Units 4 and 5 were commissioned on 19th February 2015. The two power plants each generate 150 MWe.

2.1.5 The wellhead technology

Wellhead Technology is a new power generating technology that involves tapping steam from wells which are undergoing discharge tests or waiting to be connected to a conventional power plant. Unlike the main generating power plants, it takes relatively short time (6 months compared to the 24-36 months taken by main power plants) to put up and commission a wellhead generator. This technology ensures quick return on investment from geothermal resources. KenGen is a pioneer of the wellhead technology. It has 16 wellheads installed with a generation capacity of 83.5 MWe. 15 of these wellheads are located in Olkaria geothermal field and tap steam from Olkaria East, Northeast and Domes sectors. The first Wellhead generator was commissioned in Eburru in the year 2011 with a generation capacity of 2.4 MWe. The second Wellhead generator was commissioned in June, 2012 in Olkaria East field. This has a generation capacity of 5 MWe. KenGen accelerated the installation of wellhead generators in 2014-2015. By June 2018, KenGen had installed 16 wellhead generators with an aggregate capacity of 83.5 MWe.

2.1.6 Oserian power plant

Oserian power plant is a binary plant owned and operated by the Oserian flower farm. It generates 4 MWe using steam leased from KenGen. The steam is drawn from the Olkaria Central sector. It was commissioned in July 2004.

2.2 Eburru geothermal field

Eburru geothermal field is one of the fields that has an installed generating unit. Detailed exploration studies were carried out in Eburru by KenGen between 1987 and 1989. Data from the studies indicated a resource potential which led to the drilling of six exploratory wells between 1989 and 1991. The drilled wells indicated that the area experienced temperatures of over 300ºC. The maximum discharge temperature was 285 ºC. The total output from one of the well that was able to discharge (EW-1), was 2.4 MWe. Further geoscientific studies carried out in the field from 2006 indicated that Eburru field had geothermal potential of about 50-100 MWe. In 2011, KenGen commissioned a 2.4 MWe condensing pilot power plant (wellhead unit). In 2016 and 2017, KenGen carried out more detailed exploration studies in the larger Eburru-Badlands Elementaita area. Currently, plans are underway to drill appraisal and production wells to build a high capacity power plant.

2.3 Menengai geothermal field

Menengai geothermal field is one of the latest geothermal field to be put to development. Detailed surface exploration in Menengai, Arus-Bogoria, Koros-Chepchuk and Paka began in 2004. This was done by KenGen. In 2009, the government formed Geothermal Development Company (GDC) to fast track geothermal develpment. GDC was formed as a Special Purpose Vehicle (SPV), fully owned by the Kenyan government to speed up geothermal development. Using the data from the details geoscientific studies that had been done since 2004, GDC sited the first exploratory wells in Menengai. Data from the drilled wells mapped the potential area in Menengai as being over 80 km^2 with an estimated resource potential of 1,600 MWe. So far, over 40 wells have been drilled successfully with an estimated resource potential of about 162 MWe. Production drilling is on-going in the field using seven high capacity drilling rigs.

The development of Menengai field is being underatken by GDC and Independent Power Producers (IPPs). This is under the signed Project Implementation and Steam Supply Agreement (PISSA). GDC is expected to provide steam and monitor the reservoir during generation. The IPPs are expected to finance, design, construct, install, operate and maintain the plants on a Build-Own-Operate (BOO) basis. Additionally, the IPPs have also signed a steam sale agreement with Kenya Power who will off-take the power generated by the IPPs. GDC has contracted three IPPs to construct three power plants under the

105 Mwe phase 1 of Menegai development. These are Quantam East Africa Power Ltd., Orpower 22 Ltd., (a consortium of Ormat, Civicon and Symbion) and Sosian Menengai Geothermal Power Ltd., (SMGPL). Each of the IPPs will install a 35 MWe power plant in Menengai.

Various financial partners are working hand in hand with GDC to fast track the development for Menengai geothermal field. Key among them is the Government of Kenya (GoK). The African Development Bank and the French Development Bank have been instrumental in supporting the development of Menengai field. Other partners in Menengai include the UK Government, World Bank, Scaling-up Renewable Energy Program (SREP), and others. This assistance has gone towards the purchase of drilling rigs and materials, consultancies, capacity building initiatives and infrastructural development.

2.4 The Arus-Baringo-Silali project

The Arus-Baringo-Silali block in this paper refers to the Arus-Bogoria, Korosi, Chepchuk, Paka and Silali geothermal prospects. This block, which is under the GDC, has an estimated potential of 3,000 MWe. It is expected to be developed in phases with the first phase expected to generate 100 MWe. The first phase is funded by the Government of Kenya and KfW. KfW has given GDC a concessional loan of 60M USD for the drilling of 15-20 wells. The Kenya government has funded the construction of access roads and community engagement. GDC is also planning to move its drilling rig to Paka to commence drilling.

2.5 Suswa geothermal project

Geoscientific studies were carried out in Suswa between 1992 and 1993. The studies rated the area as one of prospects with high potential for geothermal resource. The field is characterised by a potential shallow heat source at 10 km beneath the caldera. The field has an estimated potential of over 750 MWe of which 200 MWe is estimated to be in the area under the caldera floor. Basing on the attained geoscientific data, three wells have been sited on the main caldera floor. A 70 MWe power plant is programmed for development and commissioning by end of 2018. A private investor has been licensed to carry out further survey and subsequent development, subject to a specific time bound programme.

2.6 Longonot

Longonot geothermal prospect is believed to be more than 132 km². Geoscientific studies carried out in the area in 1988 revealed that the prospect has the potential to support more than a 200 MWe power plant. An Independent Power Producer called African Geothermal International Ltd (AGIL) acquired a license in 2009 to develop this prospect. Three exploratory wells have been sited using the scientific data obtained. Even though the drilling has not yet commenced, a 140 MWe power plant has been planned for construction by 2020. This is to take place in 2 phases of 70 MWe each.

2.7 Akiira geothermal prospect

Surface exploration studies were done in AKIIRA area in 1990s. The studies indicated a resource potential of over 70 MWe. In the year 2015, AKIIRA Geothermal Company Ltd drilled two exploratory wells. Temperatures of about 200°C were recorded in one of the wells. Plans are underway to carry out more detailed surface exploration before conducting further drilling activities.

2.8 Barrier geothermal prospect

Geothermal prospecting in Barrier geothermal prospect began in 1993. It was carried out by the British Geological Survey. The study indicated strong occurrence of surface manifestations, signifying a hydrothermal system. The prospect covers an area of 136 km^2 and is located in Turkana County, south of iconic Lake Turkana. In 2011, further geoscientific studies were carried out by GDC. The studies revealed a high temperature area covering an approximately 60 km^2 area with sub-surface temperature of about 281°C (GDC, 2011). The study further revealed an estimated potential of 750 MWe. In 2016, Olsuswa Energy Limited was granted a license to develop this geothermal resource. In April 2018, the Company signed a Memorandum of Understanding (MoU) with the Turkana County government involving geothermal exploration and development in Barrier geothermal complex. Currently, the Company is planning for the upcoming geo-scientific (geological, geochemical and geophysical).

2.9 Other geothermal prospects

Other geothermal prospects include Emuruangogolak, Namarunu, Lake Magadi and Elementaita. Reconnaissance studies carried out in these prospects indicate temperatures of above 200°C.

3. FUTURE GEOTHERMAL POWER DEVELOPMENT PLANS

Kenyan government has come up with the National Geothermal Strategy with the aim of further fast tracking geothermal development. The Geothermal Strategy is well articulated and guided by the Least Cost Power Development Plan 2015 through 2035 (Ministry of Energy, 2018). This strategy is anchored on the main objective of Vision 2030. The main objective for vision 2030 is transformation of Kenya into an industrialized nation with the ability to provide high quality life to all its citizens. Key to this realization is the expansion of renewable, sustainable, competitively priced and affordable energy. To achieve the high share of renewable energy in Kenya's Vision 2030 energy mix, Kenya needs to accelerate geothermal development. The Ministry of Energy has put plans to undertake high speed geothermal drilling and steam development. A total of 282 additional geothermal wells will be drilled with a steam equivalent of 1,520 MWe between now and end of 2022. Execution of this plan will follow three key steps outlined below; these are also elaborated in Tables 3, 4 and 5.

- Geothermal generation;
- Geothermal steam development; and
- Geothermal drilling.

3.1 Kenya's Geothermal Field Development Plan

The National Geothermal Strategy aims at enhancing the Public Private Partnership as well as attracting private sector investment in geothermal development. This will ensure electricity affordability to consumers. The National Geothermal Strategy has proposed field development plans based on three principles. These include Portfolio exploration, Stepwise expansion and Parallel development. Under Portfolio exploration, multiple fields are explored and evaluated simultaneously, thereby increasing the probability of having at least one viable prospect for development at any given time while reducing the chances of overlooking significant development opportunities. Stepwise expansion involves cautious incremental step development determined by reservoir data. This prevents the risk of reservoir depletion and pressure drops. On the other hand, Parallel development involves development of fields selected from the Portfolio exploration and simultaneously developing them. This speeds up development.

There are two scenarios for geothermal power development. The first scenario is the reference scenario and the second is Vision scenario. Electricity consumption is forecasted to grow in the long term by 7.3 or 9.6% per year under the reference and vision scenario, respectively. Peak demand is expected to increase to 6,700 MWe under the reference scenario and 10,200 MWe under the vision scenario by 2035. The share of geothermal on the national grid is forecasted to be 2,849 MWe under the reference scenario and 3,589 MWe under the vision scenario (Table 6) by 2035. The geothermal share is expected to be contributed by public and private entities either through joint ventures or concessions.

TABLE 3: Geothermal generation

Programmes / Projects	Objectives	Expected outcome / Output	Performance indicators	Implementing agencies	Time frame	Source of funds	Total cost (in KShs million)	Budget (in KShs million)				
								2017/ 18	**2018/ 19**	**2019/ 20**	**2020/ 21**	**2021/ 22**
Olkaria V	To increase power capacity and lower cost of power	158 MW	158 MW inst.	KenGen	2015-2019	KenGen	44,544	31,180	8,909	4,455	-	-
Olkaria I Unit 6		70 MW	70 MW inst.	KenGen	2015-2019	KenGen, JICA, EIB	22,724	2,272	13,634	4,546	2,272	-
Olkaria VI		140 MW	140 MW inst.	KenGen	2016-2020	PPP	44,544	-	4,454	26,726	8,909	4,454
Olkaria I & IV Upgrade & Top-up		47 MW	47 MW inst.	KenGen	2016-2019	KenGen, KfW	6,722	672	4,706	1,344	-	-
Wellhead modular plants		47 MW	47 MW inst.	KenGen	2016-2019	KenGen	10,300	1,030	6,180	2,060	1,030	-
Olkaria I Refurbishment		6 MW	MW inst.	KenGen	2020	KenGen	7,434	2,493	4,198	743	-	-
Menengai Phase I 105 MW (Sosian, Quantum & Orpower 22)		105 MW	MW inst.	GDC	2019	IPP	25,793	13,897	11,897	-	-	-
Menengai Phase II 60 MW		60 MW	MW inst.	GDC	2021	PPP	13,596	-	-	6,798	6,798	-
Orpower 4		60 MW	60 MW inst.	IPP	2022			2,102	4,204	6,307	6,307	2,102
Orpower 4		10 MW	10 MW inst.	IPP	2017							
Marine Power Akiira		70 MW	70 MW inst.	IPP	2022			2,453	4,905	7,358	7,358	2,453
Agil		140 MW	MW inst.	IPP				4,905	9,810	14,716	14,716	4,905

TABLE 3: Geothermal steam development

Programmes / Projects	**Objectives**	**Expected outcome / Output**	**Performance indicators**	**Implementing agencies**	**Time frame**	**Source of funds**	**Total cost (in KShs million)**	**Budget (in KShs million)**				
								2017/ 18	**2018/ 19**	**2019/ 20**	**2020/ 21**	**2021/ 22**
Olkaria IX	To increase electricity generation capacity from geothermal resources	140 MWe	140 MWe inst.	KenGen	2022	PPP	44,544	-	4,454	26,726	8,909	4,454
Menengai Phase III		60 MWe	60 MWe inst.	GDC	2022	GoK, AFD, AfDB, EIB	4,470	1,490	1,490	1,490		
Menengai Phase III		100 MWe	100 MWe inst.	GDC	2022	GoK, AFD, AfDB, EIB	7,107		1,800	1,800	1,800	1,707
Korosi Phase I		100 MWe	100 MWe inst.	GDC	2022	GoK, AFD, ELLIPSE, GRMF, KfW	7,107	1,421	1,421	1,421	1,421	1,421
Paka Phase I		100 MWe	100 MWe inst.	GDC	2022	GoK, ELLIPSE, GRMF, KfW	7,107	1,421	1,421	1,421	1,421	1,421
Suswa Phase I		100 MWe	100 MWe inst.	GDC	2022	GoK, ELLIPSE, GRMF, India EXIM, KfW	7,107		1,800	1,800	1,800	1,707

TABLE 5: Geothermal drilling

Programmes / Projects	Objectives	Expected outcome / Output	Performance indicators	Implementing agencies	Time frame	Source of funds	Total cost (in KShs million)	Budget (in KShs million)				
								2017/18	2018/19	2019/20	2020/21	2021/22
Menengai Phase III	Exploration and appraisal drilling to support 100 MW geoth. generation	35 wells	35 geoth. wells drilled	GDC	2018-2022	GoK, AFD, AfDB, EIB	19.055	523	7,688	8,048	2,796	
Korosi Phase I	To increase electricity generation capacity from geothermal sources	35 wells	35 geoth. wells drilled	GDC	2018-2022	GoK, AFD, ELLIPSE, GRMF, KfW	19,055	1,399	4,712	3,500	8,224	1,220
Paka Phase I	To increase electricity generation capacity from geothermal sources	35 wells	35 geoth. wells drilled	GDC	2018-2022	GoK, ELLIPSE, GRMF, KfW	19,055	1,399	3,500	5,400	7,880	876
Silali Phase I	Exploration and appraisal drilling to support 100 MW geoth. generation	9 wells	9 geoth. wells drilled	GDC	2018-2022	GoK, ELLIPSE, GRMF, India EXIM, KfW	5,665	59	2,060	2,060	1,486	
Suswa Phase I	To increase electricity generation capacity from geothermal sources	35 wells	35 geoth. wells drilled	GDC	2018-2022	GoK, India EXIM, Italian Dev. C., AFDB, UK Export Finance	19,055		10,926	4,120	2,060	1,949
African Geothermal Centre of Excellence	To enhance and expand geoth. energy capacity building for the country and the region	Established and equipped Centre of Excellence	Equipped Geothermal Centre of Excellence	GDC	2018-2022	GoK, ICEIDA, NDF, UNEP, GRMF	1,710	342	513	855	-	-

TABLE 6: Geothermal share and the capital investment required by 2035

		Reference scenario	Vision scenario
Geothermal expansion up to 2035	**Power**	2,849 MW	3,589 MW
	Capital requirements	$ 6.683 billion	$ 8.158 billion

To achieve the National Geothermal Strategy, six business models for geothermal development have been proposed. The Strategic Geothermal Planning Unit (SGPU) has also been set up to provide strategic leadership and prescribe business models.

3.1.1 The proposed six Geothermal Development Business Models

Table 7 presents a summary of the proposed business model while Table 8 lists the advantages and disadvantages of each of these models.

TABLE 7: A summary of the proposed six geothermal development business models

<table>
<tr><th colspan="2" rowspan="2"></th><th>1</th><th>2</th><th>3</th><th>4</th><th colspan="2">5</th><th>6</th></tr>
<tr><th>Green-field</th><th>Sale after exploration drilling</th><th>Sale after feasibility</th><th>Energy conversion / Steam sales</th><th colspan="2">Joint venture</th><th>Public model</th></tr>
<tr><td rowspan="6">Resource assessment</td><td>Preliminary survey</td><td rowspan="2">Public</td><td rowspan="3">Public</td><td rowspan="6">Public</td><td rowspan="8">Public</td><td rowspan="11">Public</td><td rowspan="11">Private</td><td rowspan="11">Public</td></tr>
<tr><td>Detailed surface exploration</td></tr>
<tr><td>Exploration drilling and well testing</td><td rowspan="9">Private</td></tr>
<tr><td>Appraisal drilling and well testing / Well head unit</td><td rowspan="8">Private</td></tr>
<tr><td>Flow testing / Well head</td></tr>
<tr><td>Feasibility study</td></tr>
<tr><td rowspan="3">Implementation</td><td>Production drilling</td><td rowspan="5">Private</td></tr>
<tr><td>Steam gathering system</td></tr>
<tr><td>Power plant construction</td><td rowspan="2">Private</td></tr>
<tr><td rowspan="2">Operation</td><td>Power plant O&M</td></tr>
<tr><td>Reservoir management</td><td>Public</td></tr>
</table>

TABLE 8: Advantages and limitations of the proposed six geothermal development business models

	Advantages	**Limitations**
Model 1: Greenfield	• Leverages most amount of private funding. • Private sector carries the resource risks. • Makes significant use of private sector expertise.	• High risk premium will result in a high generation tariff. • No debt without proven geothermal resource. Equity requirement may result in slow development. • License speculation possible.
Model 2: Sale after exploration drilling	• Proves the existence of reservoir. • Leverages significant private sector funds. • Simultaneous field development.	• High remaining resource risks • The private sector may still be unable to source for commercial funding. • License speculation possible.
Model 3: Sale after feasibility	• The existence, capacity and characteristic of the resource are proven. • Several fields can be simultaneously developed.	• All processes and data from exploration drilling needs to be produced according to global best practices.
Model 4: Steam sales	• Generation tariff is lower compared to BM1, BM2, BM3. • May attract traditional IPP's (non-geothermal). • Private sector has easier access to commercial funding.	• Significant up-front public sector investment. • Private sector requires steam sale guarantee (under steam sales). • Significant need of public assets and human resources.
Model 5: Joint venture	• Several parastatals can participate as shareholders in a SPC. • Public sector can use previous investment of fields as equity in the SPC.	• Private sector will require to be the majority shareholder with management rights. • Conflicting interests among the different parties may arise.
Module 6: Fully public	• Geothermal tariffs lowest of all potential business models.	• Increase government liabilities. • High funding requirements may be impossible to meet.

3.1.2 The proposed Strategic Geothermal Planning Unit (SGPU)

The SGPU is tasked with sector coordination, definition and implementation of geothermal policies and strategies proposed by the Ministry of Energy. The SGPU specific tasks include:

- Coordination of geothermal development in line with power development and transmission planning.
- Define the sequencing of geothermal field development.
- Review and simplify the legal and regulatory framework for geothermal energy.

- Formulate a strategy for private sector involvement in the geothermal sector that unifies the regulatory structure for geothermal development consistent with the Strategic Vision.
- Determine the business model to be applied in development of the various fields.
- Determine the timing for tendering of de-risked geothermal fields.
- Oversee tender process for award of geothermal license to IPPs including defining the technical and financial specifications by which an IPP partner will be selected.
- Formulate conditions for award of geothermal resource licenses for greenfield projects.
- Determine the pricing policy for Greenfield projects.

Other measures put in place by the government to enhance development of geothermal are:

- Enhancing the public-private partnership. Steps have been taken by the government to attract greater private investment. The formation of GDC to undertake geothermal well exploration and drilling then lease out steam to IPPs is one of such measures.
- The recently enacted mining act sets up the maximum period a lease can be held with no geothermal exploration or development work going on. This will open up geothermal prospects to able investors who are otherwise locked out by lease holders who lack the financial capability of developing these prospects.
- The plans to set up a Centre of Excellence in the country is aimed at enhancing local capacity building.

4. PROGRESS MADE IN DIRECT UTILIZATION OF GEOTHERMAL RESOURCES

Worldwide, direct utilization of geothermal energy has increasingly gained popularity due to its economic, environmental and energy efficiency benefits. Its applications vary widely from agricultural applications, crop drying, space heating and industrial processes. In Kenya, direct utilization of geothermal resources dates back to early 19th century. The Maasai community for instance is known to have used red ogre associated with the hot springs and altered ground to decorate their faces. Additionally, they used the hot springs for bathing.

The early English settlers also applied direct utilization of geothermal resources in drying of crop in Eburru. In 1939, they built a geothermal drier to dry pyrethrum and white corn. The drier was supplied by geothermal water from a nearby borehole at 95°C. However, the inadequate technology resulted in great heat loss with only 43°C being supplied in the drier. Currently, Eburru residents gather and condense some of the geothermal steam from the fumaroles for consumption as drinking water.

Large scale direct utilization of geothermal resource was first done by the Oserian Development Company Ltd. in 2000. The company started using geothermal heating and carbo dioxide supply in their greenhouse flower farms. Oserian Development leased one well from KenGen which it uses to supply heat and carbon dioxide required for photosynthesis to the greenhouses (Figure 6). The heating controls humidity especially in the morning hours when humidity tends to rise to about 100% hence, eliminating fungal infection. This reduces the use of chemical fungicides. Heated water is also used to sterilise the fertilised water, reducing fertiliser wastage and hence reducing cost. Carbon dioxide from the well is piped to the greenhouses in order to enhance photosynthesis.

In 2010, KenGen initiated a large scale direct utilization of geothermal for recreational purposes. An idea to construct a geothermal spa was conceptualised. The spa utilizes natural geothermal water from a drilled well. The water is obtained from the well at 160°C. From the well, it's pumped into a pool where it's allowed time to cool from 91°C to 85°C. It is again transferred to another pool where it's cooled further to 60°C before flowing to the main pool where visitors enjoy their warm bath at temperatures of between 40°C to 30°C (Figure 7). The geothermal Spa started operations in July 2013 and is the only natural spa in Africa. Lake Bogoria hotel have utilized hot springs for use in a swimming pool. The hot springs are directed into a swimming pool where residents and visitors enjoy a warm bath.

FIGURE 6: Oserian greenhouse heating using geothermal

FIGURE 7: A view of the Olkaria Geothermal Spa

Plans are underway to scale up direct utilization of geothermal in horticultural farming. In 2015, GDC set up direct use demonstration project in Menengai. The direct use demonstration centre is aimed at showing how geothermal by-products can benefit communities through their use in green houses, leather tannery, dairy milk preservation, fish farming, meat processing and development of spas among others. Four demonstration projects have been set up in Menengai. They include geothermal powered dairy unit, geothermal heated aquatic ponds, geothermal heated greenhouse and geothermal powered laundry unit. Pilot plants have been set up for use in these projects. This is aimed at encouraging investors to invest in direct utilization of geothermal resources.

5. OTHER KEY PLAYERS IN GEOTHERMAL SECTOR OTHER THAN KENGEN

GDC was incorporated in December 2008 as a Government Special Purpose Vehicle (SPV) intended to undertake surface exploration of geothermal fields, undertake exploratory, appraisal and production drilling, develop and manage proven steam fields and enter into steam sales or joint development agreements with investors in the geothermal sector. The formation of GDC was aimed at de-risking geothermal power development projects. GDC was established as a limited company owned by the government of Kenya with the National Treasury and Ministry of Energy and Petroleum as the shareholders.

OrPower 4 Inc., a subsidiary of the Ormat Technology operates a Geothermal Power Station on the South western slopes of Olkaria hill through a 20 years Power Purchase Agreement (PPA) with KPLC. The Olkaria III geothermal resource occurs partly within Hell's Gate National Park (gazetted in 1984), and partly in Maiella - Ngati and Kongoni farms. It falls within the zone gazetted as a geothermal resource area in 1971. Orpower 4 Inc. is in charge of developing the Olkaria Northwest sector of Olkaria geothermal field. Other than OrPower 4 Incl., other licensed Independent Power Producers (IPP) include; AGIL (IPP) for exploration and development of Mt Longonot geothermal field, Olsuswa (IPP) for exploration and development of Barrier field and Marine Power Generation (IPP) for exploration and development of Akiira geothermal field, among others.

6. BARRIERS TO GEOTHERMAL DEVELOPMENT AND THEIR REMEDIES

Geothermal resource development has a few challenges associated with its development. These challenges range from environmental and social, policy and legislative, technological and financial (Malafeh and Sharp, 2014). The challenges tend to slow down the utilization of geothermal resources. In its journey to the development of geothermal resources, Kenya has also faced these challenges. The challenges and measures put in place to solve them are outlined below.

6.1 Financial challenges

Exploration, appraisal and production drilling in geothermal development requires large up-front financial investment and the long-term investment returns. This has been a great challenge considering Kenya's low income economy. Geoscientific surface studies and exploratory drilling funding is done by the government while appraisal drilling is funded by the government and partially by private sector. The huge capital investment required has resulted in overreliance to donor funding. With such overreliance, the speed of geothermal resource development in Kenya has relied on the availability of donor funds. For instance, the withdrawal of donor funding in the 1990s saw considerable slowdown of geothermal activities in Kenya as captured in the introductory part of this report.

However, the Government of Kenya has put forth measures to curb these financial challenges. Research and Development fund has been set aside to facilitate research in geothermal industry. Revenue generating activities, for example, offering consultancy services to private geothermal companies and other countries and steam sales have been adopted by KenGen and GDC. Adoption of policies like retention of the differential in interest on on-lent funds from the government, risk credit fund and utilization of the fuel levy fund for geothermal development has created the platform for raising revenue. Grants from research proposals written by geothermal development companies have also been used to raise funds for exploration. Moreover, the government has sort to raise funds through offloading its share in KenGen and offering competitive bidding to local and international private and public institutions. Carbon credit and wellhead units also provide cash stream to expand geothermal development.

6.2 Technological and human capacity challenges

During the early times of geothermal development, Kenya lacked the required expertise to handle this new technology. Inadequate human capacity slowed down geothermal development. This was compounded by the overreliance on foreign experts which raised the cost of development. Technological challenges negatively affected geothermal development. A reduction in drawdown pressure resulted in the decline of the early drilled production wells. Low capacity drilling rigs which couldn't drill to greater depths (i.e. 2000 + m) hence leaving much of the resource untapped. Technological challenges like the low capacity rigs have been addressed through purchase of high capacity rigs with the ability to drill deeper wells (3000 + m). Modeling of re-injection plan has aided in stabilizing the reservoir drawdown pressure as well as the well output. The government has taken great effort in capacity building through sending engineers and scientists to geothermally advanced countries like Iceland, New Zealand and USA.

Experts have also been brought in the country to offer training using the local geothermal resources. This has enhanced in-house expertise. KenGen and GDC in conjunction with United Nations Environment are in the process of jointly setting up a geothermal training school (popularly referred to as Africa Geothermal Centre of Excellence) to train both local and international students to become geothermists.

6.3 Environmental and socioeconomic challenges

Kenya's geothermal resources, like most of the geothermal resources, are located in remote scenic, wild and protected areas. The key socioeconomic impact associated with developing these resources include opening up of these areas, loss of wildlife habitat and visual intrusion in scenic tourist areas. Communities living within these areas also have to be displaced due to unconducive environmental conditions that come with geothermal power development. For example, Olkaria geothermal field is located in Hells Gate national park. Development of the field takes cognizance of the likely impact of geothermal development. KenGen has signed an MoU with KWS that guides development of the geothermal resource while conserving and preserving the ecosystem. However, there are also social benefits associated with this development to the local community.

Socioeconomic challenges have been dealt with through enacting set international environmental policies that addresses such challenges. The Environmental Impact Assessment (EIA) regulations policy, National and donor emission standards for air, noise and water quality requirements, Local and international legislation in relation to biodiversity conservation, national and international policy on resettlement/relocation and compensation are among the legislation adopted by the Kenyan government to address these challenges. Geothermal development companies have environment sections which deal with rehabilitation and restoration of the affected habitat. In line with its corporate responsibility and its environmental policy, KenGen has set up Social Corporate Responsibility (SCR) programs which provide social amenities for example, schools, hospitals and animal watering points for the local communities, like in the case of Olkaria geothermal field.

6.4 Legislative and policy challenges

Before 1998, electricity generation and distribution was tasked to Kenya Power and Lighting Company (KPLC). KPC was a state-owned corporation under the Ministry of Energy. This made the development of geothermal resource a solely government affair. Owing to the limited government resources, this monopoly considerably slowed down geothermal development. The Government undertook fundamental reform process within the energy sector in 1996. A policy paper on economic reforms set out the governments intentions to separate the regulatory and commercialize functions of the sector, facilitate restructuring and promote private-sector investment. Consequently, the Electricity Power Act of 1997 reduced the government's mandate, through the Ministry of Energy, to policy formulation while devolving its regulatory mandate to Electricity Regulatory Board (ERB). This rationalization and unbundling redefined the scope of Kenya Power and Lighting Company (formerly known as KPLC) such that it was limited to transmission and distribution of electricity.

KenGen was formed through an act of parliament enacted in 1996. It was established in 1997 and its mandate was to generate electricity. The1996 Act also opened up for Independent Power Producers (IPPs) to enter electricity generation industry. Formation of the state-owned Geothermal Development Company (GDC) through an Act of parliament in 2008 enhanced geothermal exploration. GDC, formed in 2009, was mandated with exploration of geothermal resources before handing them over to KenGen or other private developers for development. The government is to source for the exploration funds.

7. FINANCING OF GEOTHERMAL PROJECTS

Contrary to what is believed, there is a lot of money chasing after funding of geothermal projects. The main qualifier is the bankability of the project. Investors and financiers will only want to put their money where there is a surety of recovering and making profits over the life of the investment. Geothermal projects have long economic life of at least 20 years and typically 25 to 30 years with payback period of about 10 to 15 years. This section is divided into the various entities (funds) involved financing which include government entity, private entity and international agencies and the financial institutions.

7.1 Government entity

Under Government entity, there are various government owned utilities which are funded through various means. For instance, national electric utilities with minority investments by either a single strategic partner, or by a large group of private shareholders are either funded through equity, sales of electricity and/or debt. Similarly, power utilities owned entirely by national government are funded by government and/or through sales of electricity. The national government also funds national exploration entities including geological survey organizations and single-interest geothermal exploration companies. These organizations also get funds through grants from international organizations. Government owned parastatals with the ability to invest in projects within the sector fund themselves with revenue from their investment. There are also national energy planning agencies, some with regulatory functions and/or with funding capability which are funded by the government. Finally, regional or local research and environmental organizations as well as development agencies are funded through national and regional governments or through grants from donors.

7.2 Private entity

Various private entities are funded through equity or debt. They include IPPs with the sole interest of developing power plants, strategic investors, often sovereign wealth funds or national parastatal companies, interested in acquiring percentage interest in low-risk geothermal projects with national entities, private developers, private equity firms, interested in acquiring percentage interest in high-return, low-risk ventures. Contractors – civil, mechanical, electrical and other potentially interested in acquiring percentage interest in geothermal projects in return for guaranteed market are funded by debt, equity and on-going sales of product. Moreover, power related equipment manufacturers who may extend vendor credits, or may be interested in acquiring percentage interest in geothermal projects in return for guaranteed sales market are funded by debt, equity and on-going sales of product.

7.3 International agencies

There are International Agencies financing institutions that both specialize with funding power generation projects; especially renewable energy. There are also those that concerned with environmentally clean energy and offer grants to clean energy projects. Aid agencies from donor from nations offering financial and technical assistance offer funds either as grants or as cost-sharing co-finance. International and regional development banks also offer funds as sovereign loans at concessionary rates which are passed on to geothermal entities at market rates. Additionally, international environmental agencies provide technical assistance and grants for specific environmental problems. Concessional loans, loan guarantees and project insurance can also be provided by import-export banks, insurance and re-insurance companies which are government owned. Finally, international and national institutions offer training and degree-granting programs at no cost or through partial remission of fees.

7.4 Financing of geothermal projects

Before a financial institution agrees to fund geothermal projects, it must prove the viability of the project. To do this, they first carry out feasibility study using experts. Various sources of funds for geothermal project include internal funding through budgeting process. KenGen has this type of funding structure. Funds can also be sourced from concessionary loans from bilateral partners for example the World Bank, JICA, EIB and KfW. Additionally, money can be raised through privatisation of corporations. Such include IPO, PIBO and Rights issue among others. KenGen has in the past raised money through these processes. In May 2006, it raised USD 109 million through sell of 30% fraction of the governments holding, which was 100% at the time. KenGen also held a PIBO in 2009 that raised over USD 295 million. Rights Issue was held in 2016 which raised USD 265 million. Companies can also get commercial loans from banks, for example, KenGen secured a loan from EXIM Bank of China to drill 89 wells. Additionally, organisations for sharing costs and benefits can also act as source of funds. Revenue streams from internal processes like consultancy services can be invested in geothermal projects.

8. CONCLUSION

Project management orientation is critical in organizations for prudent management and handling of geothermal development. Geothermal projects are capital intensive and are dynamic because they deal with new and complex technology that is constantly evolving. Kenya has proven geothermal resource potential much of which still remains untapped. Geothermal power has proved to be benign, affordable and reliable source of energy for the Kenyan electricity consumer. To meet the future power demand, the government has put up plans and strategy to fast track the development of this resource. The National Geothermal Strategy provides the roadmap for this development. Geothermal power has proved to be cheap and reliable source of energy to the Kenyan power consumer. Direct utilization of geothermal resource has also proved that it can be utilised for industrial purposes. The government aims at having more than 50% of power supply coming from geothermal by the year 2025.

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