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KENYA'S PLANS FOR GEOTHERMAL DEVELOPMENT – A GIANT STEP FORWARD FOR GEOTHERMAL

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ABSTRACT

Kenya is endowed with relative large high temperature geothermal potential estimated at between 7,000 and 10,000 MWe that is largely untapped. In tandem with and to capture the spirit of the Kenya's Vision 2030, the country has developed a least cost power expansion plan which projects that geothermal will provide an additional 5000 MWe by year 2030. The Government has incorporated Geothermal Development Company Limited (GDC) as the vehicle to realize the additional geothermal electricity generation capacity. GDC projects that for the country to achieve the additional 5000 MWe in the next 20 years, it requires to operate at least 12 drilling rigs and to raise US$ 18 billion. GDC has further established that owning the rigs would reduce drilling cost by 46% compared to hiring. The anticipated savings has motivated the country to procure its own rigs, four of which have been delivered with four additional scheduled for delivery in the next one and half year. In addition, five rigs are in operation, four of which are hired and one a refurbished one. The country will employ early power generation using modular power generation units and integrate direct use into the geothermal development strategy. Currently, 9 rigs are deployed in geothermal development while projects whose total capacity exceeds 800 MW are under implementation. An addition 800 MWe project is scheduled to commence soon.

1. INTRODUCTION

Kenya is well endowed with high temperature geothermal resources that are largely untapped. They are concentrated in the East African Rift that is associated with the worldwide rift system and is still active. The East African Rift system has been associated with intense volcanism and faulting which has resulted in development of geothermal systems. Over fourteen geothermal prospective sites have been identified in Kenya, these are; Suswa, Longonot, Olkaria, Eburru, Menengai, Arus-Bogoria, Lake Baringo, Korosi, Paka, Lake Magadi, Badlands, Silali, Emuruangogolak, Namarunu and Barrier. Figure 1 displays the location of these areas.

Studies carried out in these prospects indicate that a potential greater than 7,000MWe of high temperature geothermal exists in Kenya. Geothermal is currently the most economic base load power source and the only promising indigenous resource for development of power for the country.

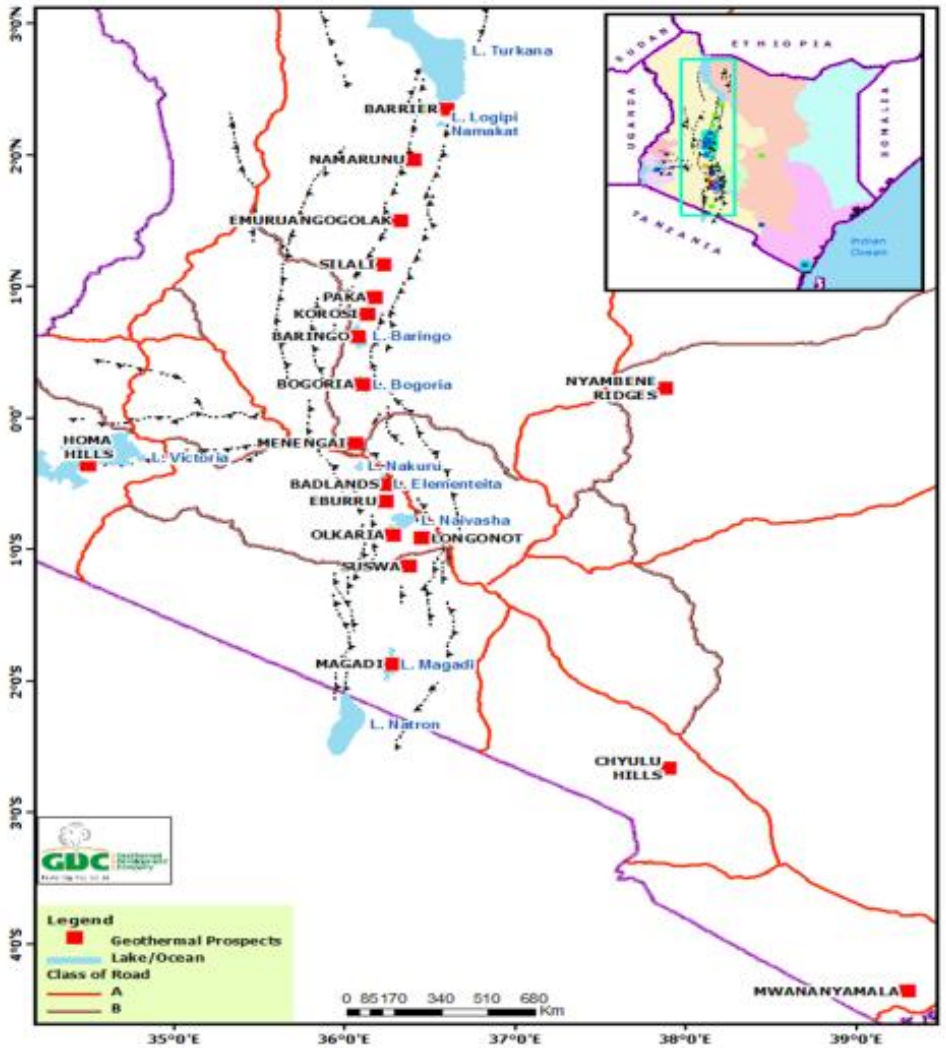

FIGURE 1: Geothermal prospects in Kenya

2. DEVELOPMENT OF 5,000 MWe BY 2030

The Vision 2030 is Kenya's development blue print covering the period 2008 to 2030. It aims at transforming Kenya into a newly industrializing "middle income" country providing quality life for all its citizens by the year 2030 (Government of the Republic of Kenya, 2007). The Vision 2030 is premised on an inorganic economic development through implementation of "flagship" projects that will spur and spiral economic growth. Electricity has been identified as one of the major enablers for the Vision 2030. In tandem with and to capture the aspiration of the Vision 2030, a Least Cost Power Development Plan (Energy Regulation Commission, 2009) has been developed. The least cost expansion plan forecasts electricity demand and establishes the most economic power generation expansion plan given the available sources of power.

According to the updated least cost power expansion plan, the total new additional generation capacity is 18,920 MW comprising of 5,040 MW geothermal, 2,400 MW new coal units, 2,000 MW imports, 4,000 MW nuclear, 2,340 MW of new gas turbines 1,440 new medium speed diesel units ,1,500 MW of wind and 200MW of Hydro Power plants.

The Government has therefore embarked on a program and strategy formulation that will result in the realization of the additional geothermal capacity.

3. CREATION OF GDC

Kenya has a long history of geothermal development spanning over 50 years. The first two wells were drilled between 1956 and 1958. The first plant, Olkaria I (Figure 2), was commissioned between 1981 and 1985. The Country to date has a total installed capacity of 211.5 MWe generated from six power plants namely 45 MWe Olkaria I, 105 MWe Olkaria II (Figure 3), 55 MWe Olkaria III (Figure 4), two plants by Oserian Development Company(4 MWe) and 2.5 MWe Eburru .

FIGURE 2: 45MWe Olkaria I Power station

As early as 1997, the need for a specialized company engaged in resource assessment was identified. This was a result of the slow development pace attributed to constraints in funds for development and institutional arrangement. It was recognized that additional development capital could be raised by independent power producers (IPP). However, there was need to create an independent entity that would prospect for the geothermal resources and make them available on a competitive basis to the then Kenya Power Company Limited (KPC), the predecessor of Kenya Electricity Generating Company Limited (KenGen) and the IPPs. At the same time, the energy sector was undergoing through a process of unbundling in order to generate focus and increase efficiency. KPC was then restructured forming KenGen so as to concentrate on power generation, relinquishing the role of the resource assessment to the Government of Kenya. Before formation of GDC, the Government experimented on issuing concessions to IPP. The results was that three out of the four concession were non-starters and the only performing has been slower than projected besides taking over a proven resource. This experience has arisen from the fact that the upstream resource exploration and appraisal risks are higher than most IPPs are willing to take and even where they are willing, they cannot secure funding from traditional financing institutions. In the Kenyan situation, it is estimated that resource assessment would cost close to US$100 million per field.

FIGURE 3: 105 MWe Olkaria II Power station

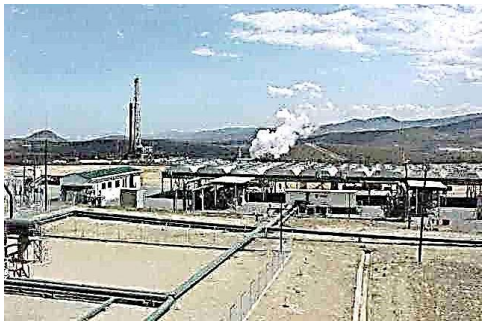

FIGURE 4: 55 MWe Olkaria II Power station

GDC was incorporated in December 2008 and mandated to facilitate the realization of the 5,000 MWe additional generation capacity in the next 20 year by assuming the upstream resources assessment risks, facilitate entry of IPP into the geothermal sector and support the Government in fund raising for geothermal development.

4. STRATEGY

It will require about US$ 18 billion to realize the 5000 MWe. The Government of Kenya recognizes that it will only be possible to realize 5000 MWe with the participation of both the public and private organizations. GDC has developed a business model whereby it concentrates on resource development and sale of steam while KenGen and IPPs buy steam and generate electricity. This strategy allocates US$ 6 billion for the Government to raise and the remainder of US$ 12 billion to

both KenGen and IPPs. The strategy further estimates that the country will require a minimum of 12 drilling rigs operating for the 20 years in order to realize the 5000 MWe goal.

5. INVESTMENT IN MAJOR ESSENTIAL RESOURCES AND INFRASTRUCTURE

5.1 Rigs

Kenya commenced the on-going drilling operation in 2007 after a lull of about 10 years, using a hired rig. Over time the hired rigs increased to 4. The average drilling costs for a hired rig is about US$ 6.5 million per well of about 3000 m depth. GDC carried out an analysis for and against owning rigs and recognized that by owning rigs the drilling cost would decrease to about US$ 3.5 million per well resulting to a saving of about 46%. Motivated by this savings, GDC has embarked on a program to purchase rigs initially numbering seven and over time to be increased to twelve. To date two rigs have been delivered (Figure 5), two additional rigs are scheduled for delivery in the 1st quarter of 2012 and the country has commenced the purchase of two additional rigs to be delivered in the 1st quarter of 2013. In addition, KenGen has procured two rigs and has rehabilitated its old N370 rig. Together the Country will have nine rigs by late 2013.

FIGURE 5: One of the new GDC 2000hp rig

The GDC rigs have been supplied complete with the drilling compressed air package; bulk cement handling and storage facilities including a cement testing laboratory; directional drilling tools and equipment; and rig camping facilities.

5.2 Human resource capacity development

As a result of 5000 MWe development goal, for a 12 rig operation, Kenya will require to develop a 1000 strong technical team ranging from scientists and engineers; to drilling crew; and field and laboratory technicians, who will be involved in the geothermal resources development. In addition, over time, installation of about 50 plants each of 100 MWe will require an additional 1000 technical staff to man the plants. All together, the geothermal industry in Kenya will offer direct employment opportunities to between 3000 and 5000 people.

Kenya has had only one rig operation team numbering about 200 people in the resource development. This team has formed the backbone of the geothermal resourced development expansion plan that the Country is undertaking. There is however a capacity gap that requires to be speedily filled. The country has greatly benefitted from training offered to the locals by the drilling contractors currently operating in the country especially in rigs operation and skills brought into the country by some staff who have worked on oilrigs worldwide.

Kenya is employing enhanced skills development approaches to meet the skills gap especially on-the-job and group trainings rather than individual training. Kenya has further entered into collaborations with training institutions most importantly the United Nation University – Geothermal Training Program in Iceland to facilitate enhanced training. Further, expertise brought into the country to fill in skill gaps enjoins training as a deliverable so as to enhance on-the-job training.

5.3 Field and laboratory tools and equipment

Kenya has invested heavily in tools and equipment for the field and laboratory, readying herself for the increased pace of development. The country has acquired Atomic Absorption Spectrometer (AAS),

XRD and Gas Chromatography among many other laboratory tools and equipment, TM and TEM alongside other field equipment, silencers, downhole logging tools and equipment including logging trucks.

5.4 Training Institute

The 5000 MW industry Kenya is embarking on will require not less than a 2000 strong highly knowledgeable and skilled workforce for its long term sustainability. Geothermal training is procured overseas in very few institutions mainly in Iceland, New Zealand, Italy, United States and Japan. A typical 6 months course costs close to US$ 100,000 per person. Considering the need for staff replacement arising from retirement, natural attrition and need for refresher courses, dependency on overseas training would amount to heavy investment which may not be sustainable in the long run and not a very efficient way of using limited financial resources. On the other hand, Kenya has invested in rigs, laboratory and field equipment and is undertaking a long term development program. By these, Kenya has already acquired the most essential infrastructure for an effective base for a geothermal training program. In line with its mandate to development the necessary human resource capacity within the country, GDC has commenced plans to actualize a training institution which will serve the Eastern Africa region. In collaboration with the UNU-GTP, Kenya is already conducting a one month annual training, open to the region facilitated by experts from Iceland, Kenya and the region.

6. RESULTING OPPORTUNITIES

6.1 Early power generation using modular plants

The early power generation using modular power generation units (Figure 6) will be an integral part of the geothermal development projects in Kenya. This is because the country's power requirements are growing and the alternative sources of power are way more expensive than geothermal. In addition, Kenya has carried out financial models (Ngugi, 2012) and demonstrated that use of the early generation reduces the project capital requirement by a margin in the order of 30% and the final generation tariff in the order of 20%. This assumes a project implemented period of seven years. The common thoughts are that the 5-10 MWe portable modular units will be relocated to give way to the larger more permanent plants. However, this need not be the case as both the modular and larger plants can generate alongside each other.

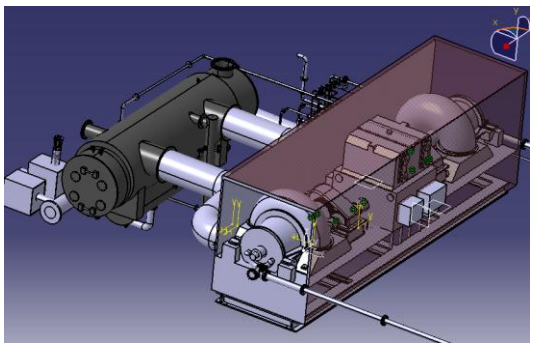

FIGURE6: Modular generation plant (Source Kaldara)

6.2 Consultancy

It is estimated that the Eastern Africa geothermal potential is over 15,000 MWe which is highly understated. At the same time, the area suffers great power shortage with a few countries being forced to employ very expensive emergency power. Coupled with the global warming that has favoured development and financing of renewable energy, and the Kenya success story, more countries in the region have developed great interest to utilize their geothermal potential. Kenya has invested in a lot of the necessary infrastructure which includes human resource, field and laboratory equipment, well testing and drilling equipment. These resources will therefore come handy for the countries that are starting. Kenya has already consulted for a few countries including Rwanda, Comoros, Malawi, Zambia, and Yemen. GDC is seeking to enter into collaborations and joint ventures with overseas consultants and contractors providing services to the region in order to support growth of the geothermal sector in the region.

6.3 Direct use

Kenya leads the world in the largest rose flower cultivation utilizing geothermal resources (Figure 7). M/s Oserian Development Company Limited is using geothermal in its 50 hectare rose flower greenhouses in four ways, namely, injection of carbon dioxide for increased growth rate, sterilization of fertilized water and conditioning of the greenhouses for reduction of diseases and water requirement. In addition, they generate power using modular plants thus reducing their overall cost of production. The firm employs about 5000 staff.

FIGURE 7: Greenhouses utilizing geothermal resource in Kenya

Geothermal development gives rise to various by-products, namely: - low quality heat in separated brine, non-condensable gases mainly carbon dioxide and hydrogen sulphide and water (separated brine and condensate). Kenya is an agricultural country that produces various products which require heat for processing including corn (maize), pyrethrum and dairy products. In addition, water is a precious input for both animal husbandry for watering animals, growing fodder and for crop production through irrigation. Together with generated electricity, the by products offer a very important opportunity for commercial activities both in the agricultural, tourism and industrial sectors. Kenya has a very low employment rate. As a consequence, one of the most desired impacts by the projects' host communities is job creation. GDC has estimated that the indirect job creation by integrating direct use and industrial development with the electricity generation will be approximate 5 million. Not only will job creation economically empower the host communities, but the huge disposable income will attract infrastructure and other services thereby improving the quality of life for the host communities.

7. CONCEIVED AND PROJECTS UNDER IMPLEMENTATION

7.1 280 MWe Olkaria I & IV

The 280 MWe Olkaria I and IV project entails installation of two power plants each of 140 MWe (2 x 70 MWe). The steam for the one power plant has been obtained by drilling within the Olkaria I and II steam field while for the second power plant has been obtained by successful expansion of the Olkaria steam field. GDC has developed the steam and KenGen will install the power plants including the steam gathering network. To date steam equivalent to 360 MWe has been availed and construction activities have commenced. The plants are scheduled for commissioning by early 2014. Four rigs are working in this project.

7.2 75 MWe Olkaria Modular Power Plants

In 2009, the country suffered major power shortage occasioned by drought which reduced the effective hydro capacity from about 760 MW to as slow as about 200 MWe, resulting to load shedding. Drilling for the 280 MWe commenced in 2007. By 2009, there was over 120 MWe worth of steam on the wellhead that was idle. An idea was mooted to employ early generation using the wellhead modular power plants which had shown to be financially viable. The modular units were to be relocated to other developments upon commissioning of the main power plants. The first plant of 5 MWe is under commissioning by KenGen and GDC has just awarded the installation of one unit at Menengai.

7.3 280 MWe Olkaria expansion

Drilling at Olkaria IV has resulted in a better steam yielding field at Olkaria. To date the field has over 190 MWe worth of steam on the wellhead but the field is yet to be delineated. Consequently, a further resource assessment has been commissioned in order to establish whether the Olkaria I, II and IV steam field can support an additional 280 MWe.

7.4 36 MWe Olkaria III expansion

Olkaria III commenced operation in 2000 with a capacity of 8 MWe. Overtime, the capacity has been increased to 13 MWe (March 2002) and to the current generates 48 MWe (excluding parasitic load) achieved in 2009. The plant is scheduled for an additional expansion of 36 MWe to a total generation capacity of 84 MWe. One hired rig is currently operating in this project.

7.5 400 MWe Menengai Phase I

Detailed surface studies in Menengai geothermal field was carried out in 2004 and updated in 2010. The study showed that there existed a high temperature resource whose potential was estimated at 1650 MWe. The first exploration well was successfully drilled in 2011. To date six wells have been drilled to completion three of which have been tested with a combined steam capacity of about 25 MWe. GDC plans to deploy six rigs in the prospect, two of which are already in the project site. The project aims to install 4 x 100 MWe to be commissioned in the 2015/16 financial year.

7.6 5-10 MWe Menengai Modular plants

As noted above, steam has already been proven within the Menengai field. The main power plants are scheduled to be commissioned in the next four year. There exists therefore a four year opportunity for utilization of early generation modular power plants before commissioning of the main plants. GDC has selected an investor who is expected to commission the first 5-10 MWe unit by mid-2013. Additional modular power plants will be installed as steam becomes available.

7.7 800 MWe Bogoria – Silali

The Bogoria Silali block is comprised of the Bogoria, Paka, Chepchuk, Arus and Silali prospects. Together the block is estimated to have a potential of about 3000 MWe. Various studies have been undertaken in these fields. GDC is currently updating the studies with a view to advance the prospects to exploration drilling. All the prospects are close to one another. The area has limited infrastructure particularly in roads and water supply. GDC has therefore devised a strategy to develop infrastructure that serves all the prospects so as to minimize infrastructure cost. It is planned that the first project will aim at 800 MWe and will be undertaken using 8 rigs. GDC and the Government are seeking financing to establish the necessary infrastructure and for hiring at least a rig for exploration drilling. It is planned that exploration drilling will commence in the next financial year.

8. CONCLUDING REMARKS

- Kenya is well endowed with a large, high temperature geothermal capacity estimated at between 7,000 and 10,000 MWe which is largely unexploited,
- In line with and to capture the spirit of Vision 2030, the country has embarked on a program to develop 5000 MWe in the next 20 years,
- The Government has incorporated GDC as a special vehicle company to facilitate prospecting and development of the geothermal resources and sale steam to power generators,

- Motivated by substantial projected savings, GDC has opted to buy rigs rather than hire. Altogether GDC projects to own and operate six rigs by mid-2013 at which point in time the country will possess nine rigs. Currently, nine rigs are deployed to the various projects ongoing in the country,
- The country has also made investments in the necessary laboratory and field tools and equipment,
- The country is in the process of establishing a geothermal institution to train the over 2000 workforce necessary to sustain the 5000 MWe geothermal industry,
- Modular generation units will become an integral part of geothermal projects in Kenya because it has been shown they reduce project capital requirement by a significant amount and result to lower generation tariff,
- Integration of direct use in electricity power project has a great potential to create large employment opportunities that is a highly desired social impact in Kenya,
- In Kenya, geothermal projects whose total capacity exceeds 800 MW are currently under implementation while an additional 800 MWe project is scheduled to commence soon.

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