COUNTRY UPDATE REPORT FOR KENYA 1991-1994

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KEY WORDS: Geothermal Energy, Kenya, Olkaria, Public Sector, Private Sector

1. INTRODUCTION

This paper is an update of the development activities that have taken place in the geothermal sector during the period 1991-94 in Kenya. This covers the work undertaken by the Kenya Power Company Ltd, which is the government's executing agency for the geothermal program. It takes into consideration exploration work initiated by the British Geological Survey, who were the only other agency involved in geothermal resource assessment or development in the country

During the period under review, Kenya, among several African states. was undertaking some Structural Adjustment Programmes in the political and economic fronts, as agreed with the donor community. As a result of this, a number of projects which were programmed to be executed during this period were delayed, pending implementation *of* several policy *reforms. Among these is* creating an enabling environment that will allow private sector participation in the power industry, which will reduce the overall commitment of the public sector in future generation installations.

Because grothermal energy has been identified as the least-cost source of energy over the next 20-year planning period (Acres, 1987), and there being abundant manifestations of its occurrence in the country (Ojiambo, 1990), it is therefore an attractive candidate for private sector participation (KPC, 1992). Consequently, work 'has continued on the identification, investigation and documentation of additional areas for future developments. This is in recognition of the fact that the public sector may be called upon to take some of the initial risk before the areas are attractive to private entrepreneurs.

A total of 448MWe (KPC, 1994a) of additional geothermal energy is envisioned upto the year 2012. *This will represent about 30% of* Kenya's power requirement.

2. EXPLORATION ACTIVITIES

Scientific investigations continued in the Olkaria Geothermal Field (Figure 1) to consolidate and refine the available information.

Reinjection of Lake Naivasha water with a flourescein tracer was done in well OW-3 in the Olkaria East Production Field. Tracer return was observed in wells OW-2, 4, 7, 8 and 11. *An* increase in output was noted in well OW-4 (Ambusso. 1993).

Discharge testing was completed in all drilled wells in the Olkaria North-East Field. Tested output is 77.3 MWe. A 64MW power station is planned in this area. In addition, tracer injection into well OW-704 was started and interference testing of wells OW- 707, 724 and 723 *to refine the proposed reinjection scenario for the* planned station. The production wells are 714, 716 and 725. Due to environmental (KPC, 1993) and reservoir requirements, all separated and blow dawn water from this station will be reinjected.

Based an resistivity measurements, two sites were identified in Olkaria West (AA and DD) to delineate the boundaries *of* an area Cr two future stations of 64MWe each. Drilling of well OW. 308 has already hcen started on site AA and will be completed before the end of 1994. Similarly, well OW-202 in Olkaria Central is at 1987 metres **deep.**

Well OW-101 in Olkaria Central area has been released to a neighbouring horticultural farm (Oserian Development Company) for direct use of the discharge fluids in greenhouse heating and soil fumigation This farm is a major exporter of cut flowers and in order to ensure that geothermal activities have minimal impact on the flower business, a joint trial is in progress on two plots about 600m apart near the existing station on various varieties of flowers. The control plot is about 5km from the station.

Surface reconnaissance work in Olkaria Domes and Suswa (Figure 2) which is to the south of Olkaria started in early 1992. Geothermal manifestations in these two areas *are* in the form of fumaroles and altered ground. Intensive geological, geophysical, and geochemical investigations, were subsequently undertaken together with environmental base-line studies and an integrated report compiled (KPC, 1994b).

Outside of the Olkaria Geothermal Field, the British Geological Survey completed a regional survey of geothermal activity in the Rift Valley (Dunkley et al., 1993) and proposed several areas that merit additional investigations.

3. DRILLING ACTIVITIES

An update of the wells drilled since the last Country Report (Ojiambo, 1990) is presented in Table 1

Apart from the two Eburru wells, the rest of the wells have the following drilling programme, barring Some minor variations which would be unique to a particular site:-

Surface Casing

A 26" hole is drilled to 60 metres with bentonitic mud having a marsh funnel viscosity of 60 - 80 seconds. A *20"* mild steel surface casing is then run in the hole in 10 metre joints which are welded together. The annulus is cemented back to the surface. Displacement of the cement from the casing is with water, The bottom joint is left with cement. Upon setting of the cement, the casing and the blowout preventer stack is pressure tested to 300 psi far 10 minutes.

Anchor Casing

A 17 1/2" hole is drilled to 300m with a Bottom Hole Assembly consisting of bit, hit sub, 8" drill collars and a stabilizer or 3-point reamer 20 metres above the bit. The drilling fluid is also mud for this section *of* the hole. Where uncontrollable loss of circulation occurs. drilling often proceeds blind with high viscous mud sweeps every 5 metres.

A 13 3/8" caring is run in the hole and the annulus cemented back to the surface. The casing is K55 grade steel with Buttress Thread Coupling. The top two joints are 68 lb/ft in weight while the balance is 54.5 lb/ft. After the cement has set, the blowout preventer and casing are tested to 1000psi before further drilling.

Production Casing

This section of the hole is drilled with a 12 114" bit to 700 metres. The Bottom Hole Assembly consists *of* 8" drill collars with a stabilizer or 3-point reamer 20 metres above the bit. The drilling fluid initially is mud or water but this is changed to foam if, or when. loss of circulation is encountered. The parameters for foam drilling arc as follows:-

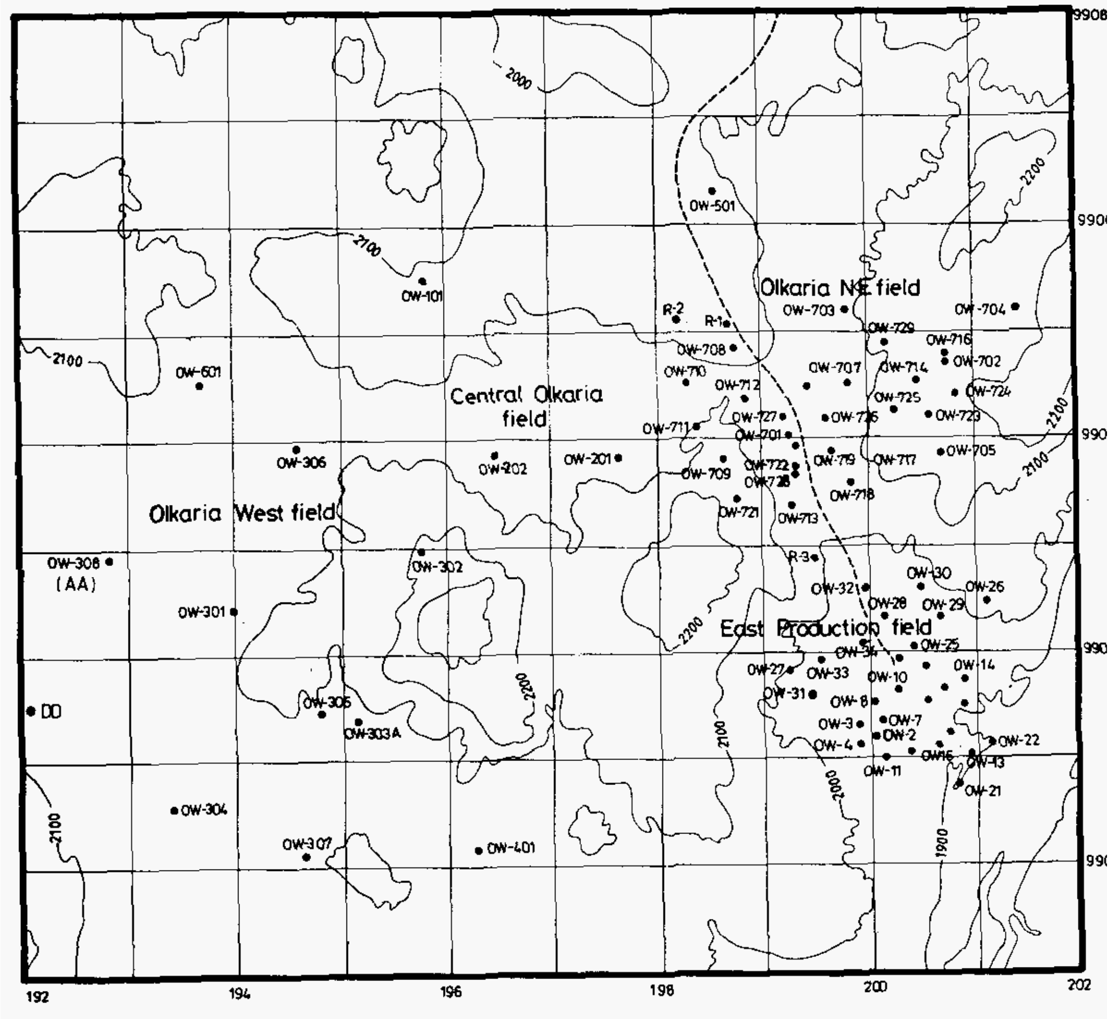

Figure 1. Location Map of Olkaria Geothermal Field.

air	: 20 - 30 m^3/min
water/soap	: 100 - 200 l/min
snap concentration	: 0.5% oftotal water flow (60 l/hr)

However. this fluid degrades and results in poor hole cleaning when temperatures are high (60-SOT) or when the hole is making water. In this case aerated water is used. To achieve this, the water flow rate from the slush pumps is increased to 1000 lpm and the air to 30 - 40 m^3/min. About 20 l/hr of soap may be used but this may vary depending on the efficacy of hole cleaning.

A 9 5/8" casing is run in the hole and cemented back to surface. The casing is 47 lb/ft in weight, grade K55 steel with Buttress Thread Couplings. Once the cement has set, the casing and blowout preventer stack are pressure tested to 1000 psi for 10 minutes.

Production Hole

A 8 1/2" hole is drilled to the total depth of the well, which is about 2200 metres from the surface. The drilling fluid is aerated water as in the previous section of the hole. The Bottom Hole Assembly consists of 6 1/4" drill collars with a stabilizer 20 metres above the hit. 7" slotted liners are landed on the bottom of the hole once the total depth is reached. The top two joints are not slotted and at least one complete joint is inside the production casing shoe. The top joint is belled out to the inside diameter of the Production casing, while the bottom joint is made in the form of a spear. The slots are 6" x 1/2" in size and are gas-cut. There are 148 slots per each joint of liner The latter is *26* lb/ft in weight, grade K55 steel with Buttress Thread Coupling.

On completion of drilling activities, the well is capped with a 10" Class 600 master valve whose bottom is an adaptor/erosion shield fitted to a 13 3/8" Casing Head Flange. A typical well drilled to 2200 metres following the above programme would take an average of 37 days to complete and cost US$ 950,000. The two wells in Eburru followed a similar programme but the casing strings were set deeper because of the altitude, which is 600 metres above Olkaria. Each of these wells cost US$ 1.5 million.

4. POWER GENERATION

A 45 MW geothermal station (3 x 15MW units) was in operation in the Eastern Production Field during this period. All units had very good availability Efficiency tests carried out in 1991 (Mureithi, 1991) show a specific steam consumption of 8.94, 9.66 and 8.94 kg/KWh for Units 1, 2 and 3 respectively. These are very close to the values obtained during commissioning.

Unit 3 machine was overhauled after operating for *52,812* hours. The rotor. casings and diaphragms, among others, were in good condition However. significant replacement of coaling tower grids and timber was made. Similarly, Unit 2 machine was overhauled after 74.223 hours. Slight silica deposits were noticed on turbine rotor blades and diaphragms and also, some pitting on the 3rd and 4th stage blades. Nevertheless, all the 3 units (Unit 3 having been overhauled in 1988) have exhibited very good perfomance since their installations in 1981, 1982 and 1985, respectively. However, the present generation is only 31 MWe as a result of a decline in steam output of the connected wells. This had been predicted in numerical simulation studies (Bodvarsson, 1988) and makeup wells had been drilled in anticipation of this shortfall. Four of these (OW-27, 28, 29 and 30) with an output of 17 MWe will be connected to the station by November, 1994. As this will only bring the station to full capacity without any reserve, an additional four wells (OW-31, 2 ; and 34). with a tested output of 15 MWe, are programmed for connection so that the station retains full capacity to beyond the year 2000.

A 64MW (2 X 32MWe) geothermal station which was planned for commissioning in the Olkaria North East Field during this period was delayed for reasons mentioned in the introduction. There are indications that tendering far the construction will start in 1995.

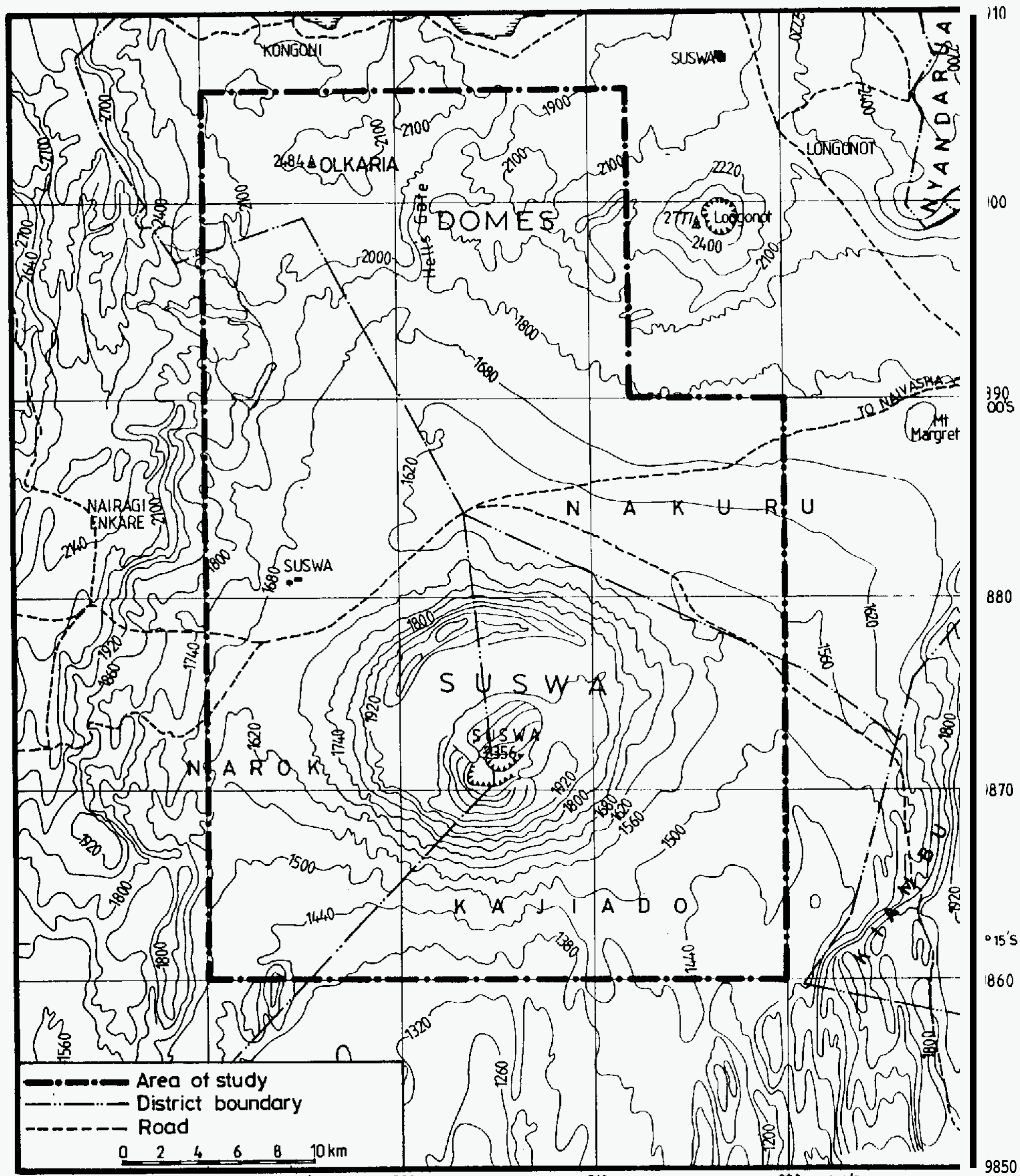

Figure 2. Location Map **of** Olkaria **Domes** and Suswa Geothermal Prospects.

5. CAPACITY BUILDING

Significant infrastructure and human resources development took place to upgrade the country's in-house capability in grothermal resource development and management. Specialised scientific equipment were procured through World Bank funding to improve on data acquisition, analysis and interpretation. A computer network was installed in the geothermal project at Olkaria and this will eventually be interfaced with the Head Office computers to improve on Management Information System.

Several professionals (University level) involved in geothermal development were exposed to the latest developments in the industry through participation in international workshops, seminars and courses as indicated in Table 2.

4 Geothermal Drilling Technical Assistance Program which was substantially funded by the Petro-Canada International Assistance Corporation (now dissolved) finally came to an end in early 1991. Since then, responsibility for project managemenl and drilling operations, as well as scientific and other support services, bas minimal external support. Nevertheless, there are areas where in-house capability is still inadequate (e.g numerical simulation, pipeline design, etc) but this **is** being reviewed in order **to** redress the situation. It is, however, recognised that some of the **work** would still initially be more cost-effectively done **by** specialised external service companies (e.g. cementing) until such time that the local capability, where developed, shall sustain the level *of* performance

TABLE 1. WELLS DRILLED FOR ELECTRICALAND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 1990 TO DECEMBER 31,1994

(Does not include thermal gradient wells less than 100m deep)

1) Type or purpose of well
T = Thermal gradient or other scientific purpose
E = Exploration
P = Production
I = Injection
C = Combined electrical and direct use

2) Total flow rate at given wellhead pressure (WHP)

Locality	Year Drilled	Well Number	Type of Well(1)	Total Depth	Max. Temp.	Fluid Enthalpy	Vell Output(2)	
							Flow Rate	WHP
				m	agrees antigrade	kJ/kg	kg/s	bar
Olkaria North	1991	720	P	2172	324	2287	5.8	6.0
East Field	1991	721	P	2201	305	1572	22.9	7.2
	1991	722	P	2198				
	1991	723	P	2203	321			
	1991	724	P	2203	326	1073	16.4	6.C
	1991	725	P	2200	313	1381	23.8	6C
	1991	726	P	2203	306	1614	20.1	6C
	1991	727	P	2201	314	1846	13	6C
	1993	728	P	2200	296	1680	24.2	6.C
	1993	708	P	2201	324	1100	15.3	4.1
	1993	R2	I	2200	287.2			
Olkaria East	1992	31	P	2001	270	2183	5.8	5.(
Field	1992	32	P	2000	303	1952	28	19.9
	1992	33	P	2000	308	2359	8.4	5.(
	1992	34	P	2131	270	2671	8.2	5.3
	1994	R3	I	2200	148*			
Olkarla West								
Field	1993	308+	E	725				
	1993	202+	E	1987				
Eburru Field	1989	EW-05	E	2217	150			
		EW-06	E	2481	220			
Total	2C							

* Reading after landing slotted liners

\+ To be completed to a total depth of 2200m

Table 2. Description of the participation of professional staff in international workshops, seminars and courses since 1991

DESCRIPTION	1991	1992	1993	1991
1. Geothermal Technology (Auckland)	2	2	2	1
2. Geothermal Technology (Iceland)	1	2		
3. World Geological Congress (Japan)		2		
4. Annual GRC Meeting	2	3	3	3
5. NewZealand Geothermal Workshop	2	3	3	
6. Stanford Workshop				2
7. Horizontal Well Drilling Technology		1		
8. Drilling Rig Maintenance and Management	3			
9. Supervision and Management	1	1	2	
10. PhD Programme		1		
Total	**11**	**15**	**10**	**6**

6. CONCLUSION

While there was appreciable increase in geothermal development activities, especially in exploration and drilling, the level of generation from the existing station dropped by 3MWe and the anticipated new station in Olkaria North East was not constructed. Fortunately, due to the central role power generation plays in the increase of revenue, both issues should be resolved by the end of 1994. As indicated elsewhere, the power industry in the country will be opened up to allow competitors, especially in power generation. The geothermal section will be a prime candidate for this development. It is therefore likely that in the not-too-distant future both public and private companies will be involved in development of geothermal resources, principally for generation of electrical power. The public sector may have to minimise the initial risk to attract private developers.

ACKNOWLEDGEMENTS

I would like to thank the Management of the Kenya Power Company Ltd for granting approval for the publication of this report. I would also like to record my appreciation to all those who, in whatever manner, assisted during the preparation of the manuscript, and for Miss Jescah Makotsi for typing it.

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