KENYA ELECTRICITY GENERATING COMPANY PLC.

KGN-SBP-010-2018.

EXPRESSION OF INTEREST (EOI) FOR RESEARCH SERVICES FOR MINERAL EXTRACTION FROM GEOTHERMAL BRINE.

10th January, 2019.

CLARIFICATION NO 1.

In Accordance with the EOI for "Research Services for Mineral Extraction from Geothermal Brine." KenGen hereby issues **Clarification No.1**

1) If you have a general thermodynamic description that would be helpful. If not, we need to know at a minimum:

a) The temperature of feed and required temperature of final brine

The two phase fluid (steam and water (brine)) for the field is separated at as follows:

- Olkaria North East: 5 bar-g (~157°C)
- Olkaria I AU 4&5: 11 bar-g (~187°C)
- Olkaria 4: 11 bar-g (~187°C)

This would essentially be the feed in temperature. The separated water temperature (or pressure) is determined by the amount silica in solution. The idea is to keep the concentration of silica in the brine (water) at below the amorphous silica saturation so as to avoid scaling of the wells/separator stations and reinjection wells. Amorphous silica solubility curve is shown Figure 1.

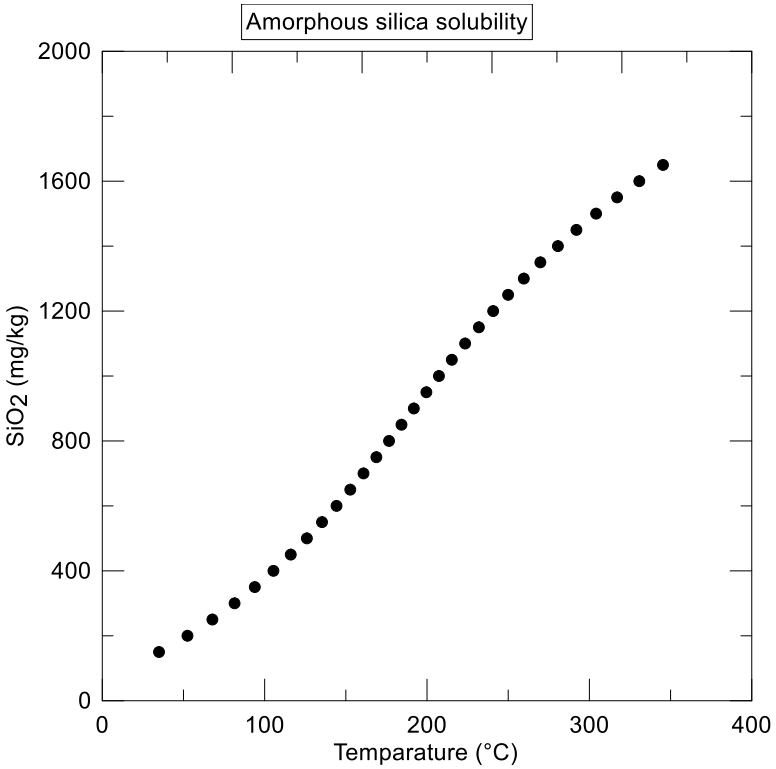

Figure 1. Amorphous silica solubility curve

The final temperature of the brine is dictated by the silica in solution and if extraction of silica from solution is carried out, the final temperature of the brine is determined by how much of the silica is left in solution after the extraction processes. At 187°C for example, the amount dissolved silica at equilibrium with amorphous silica is ~870mg/kg. Further lowering of temperature will lead to supersaturation with respect to amorphous silica leading to precipitation/scaling.

b) Flow rate

The discharge rate (brine) for production wells connected to Olkaria I, Olkaria I AU 4&5, Olkaria II and Olkaria IV is indicated in Table 1. Brine from Olkaria IAU 4&5, Olkaria II and Olkaria IV is taken into reinjection wells at the temperature of separation. The injected brine is split into several reinjection wells. An example of reinjection wells and their brine flow rate is shown in Table 2. The volumes of the brine injected into each well may vary from time to time.

Table 1. Brine output summary for Olkaria Field

Plant	Installed Capacity MWe -Gross	Enthalpy (kJ/kg)	Brine (t/hr)
Olkaria I	45	2154	156
Olkaria IAU	150	2174	420
Olkaria II	105	1764	560
Olkaria IV	150	1879	815
Wellheads	81	2144	493
Total	531	2001	2444

Table 2. Reinjection wells flow rate

Olkaria II		
Well	Enthalpy, KJ/kg	Brine Flow, t/h
OW-703	~670	225
OW-704	~670	-
OW-708	~670	80
Olkaria IV		
OW-906	~798	-
OW-906A	~798	-
OW-911	~798	12
OW-911A	~798	380
OW-913A	~798	430

c) Lithium concentration and d) Other target mineral concentrations (e.g. Mg, Co, V, etc).

Chemical analysis for a select reinjection wells is shown in Table 3 below. The lithium concentration for most part is below 2mg/kg while that of Mg is below 0.05 mg/kg. Other analysis like Co and V is not available and can be a subject of the research problem.

Table 3. Analysis result of brine form reinjection wells

Well No	Cond (µΩ/cm)	TDS (ppm)	pH/ °c	B	SO_4	Cl	CO_2	F	H_2S	SiO_2	Ca	Li	Na	K	Mg
				……mg/Kg……											
OW 703	3130	1570	9.59/20	2.34	19.1	510	277		62.2	694	0.071	1.525	508	78.6	0.038
OW 708	2820	1360	9.17/20	1.65	33.4	560	204	44.18	30.6	836	0.42	1.358	530	108.8	0.026
OW R3	3860	1930	9.56/20	2.3	39.2	660	196	67.17	21.3	854	0.176	1.376	520	95.7	0
OW-911A	2470	1230	10/20		10.19	440	320	171.3	19.7	521		1.398	490	107.1	
OW-913A	2400	1200	10.33/20			460	250	131.42	16.0	883	0.186	1.353	565	151.2	0.082

ACKNOWLEDGEMENT OF CLARIFICATION NO 1.

We, the undersigned hereby certify that the Clarification is an integral part of the document and has been incorporated in the tender proposal.

Signed……

Tenderer……

Date…….....