MAINTENANCE OF OLKARIA 1 ADDITIONAL UNITS (AU) POWER PLANT

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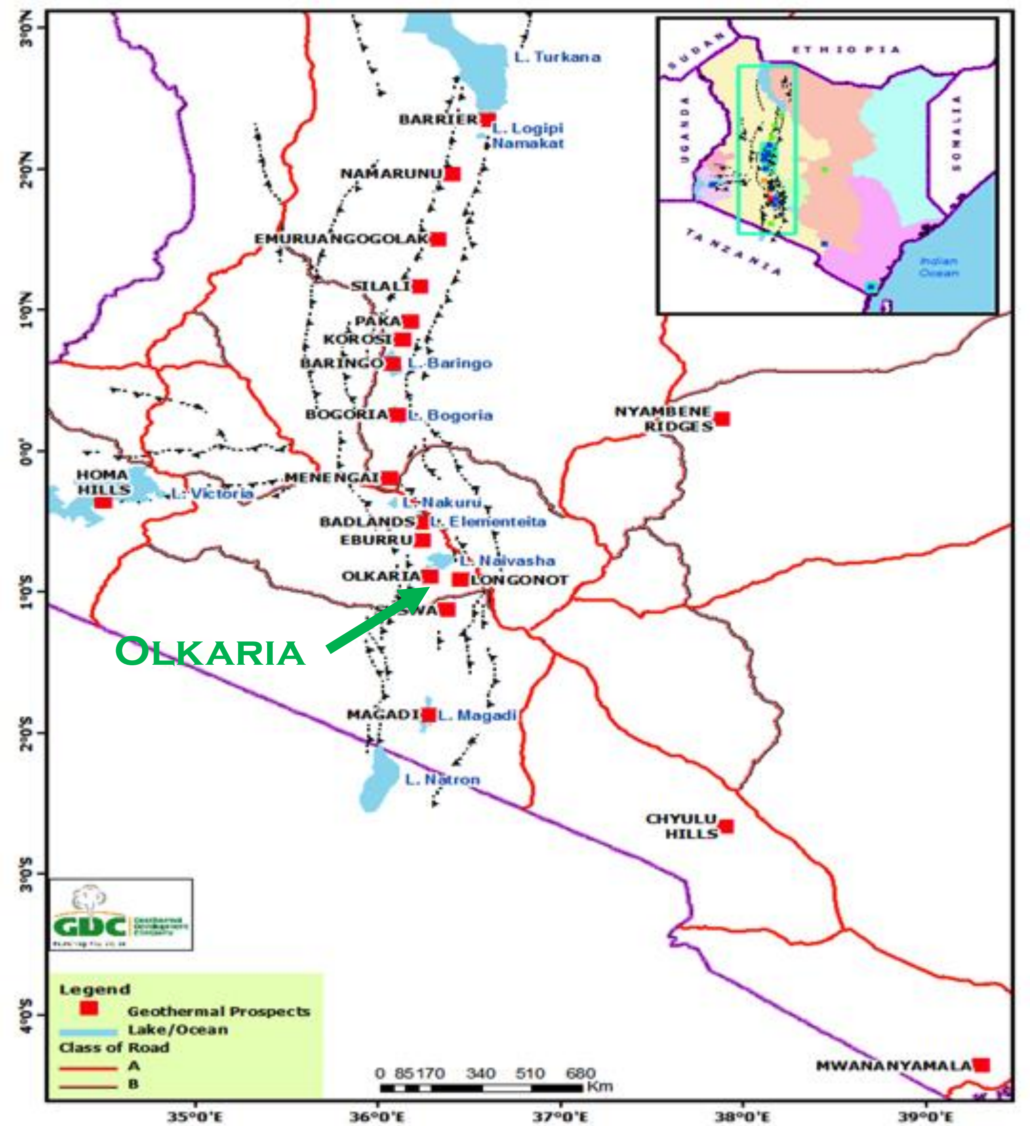
KenGen

GEOTHERMAL MAP IN KENYA



INTRODUCTION

- Kenya commissioned the 280MW in 2015.
- 280MW project consists of Olkaria IV and 1AU.
- Plant built in stages i.e. Unit 4 and Unit 5
- Commercial operation (140MW) began in January 2015
- 1AU Commissioned in February 2015.

- Financed by a loan from Japan and constructed by a consortium of Toyota Tsusho Corporation (Japan) and Hyundai Engineering (South Korea).

Geothermal Resource

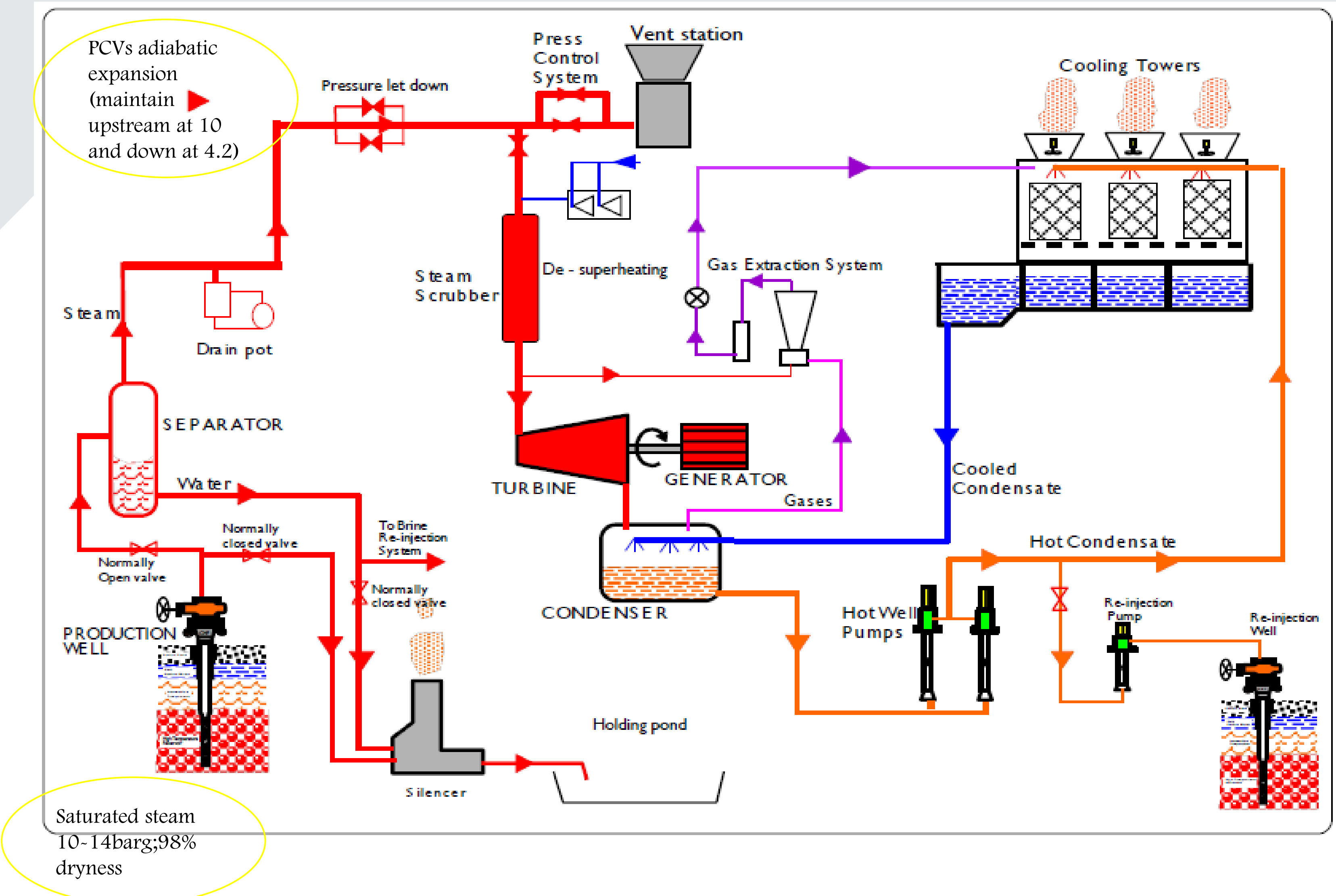
Description	Quantity	Specifications
Production Wells	26	Drilled between March 2009~March 2012 at average depth of 3000m.
Well Enthalpies		Average 2300kJ/kg
Hot Reinjection Wells	3	Average 600m
Cold Reinjection Wells	7	Range between 900m~1700m

Scope of Maintenance

System	No. of Staff
Steam Gathering	15 (Team plus supervisor)
Power Plant	11 (Team plus supervisor)

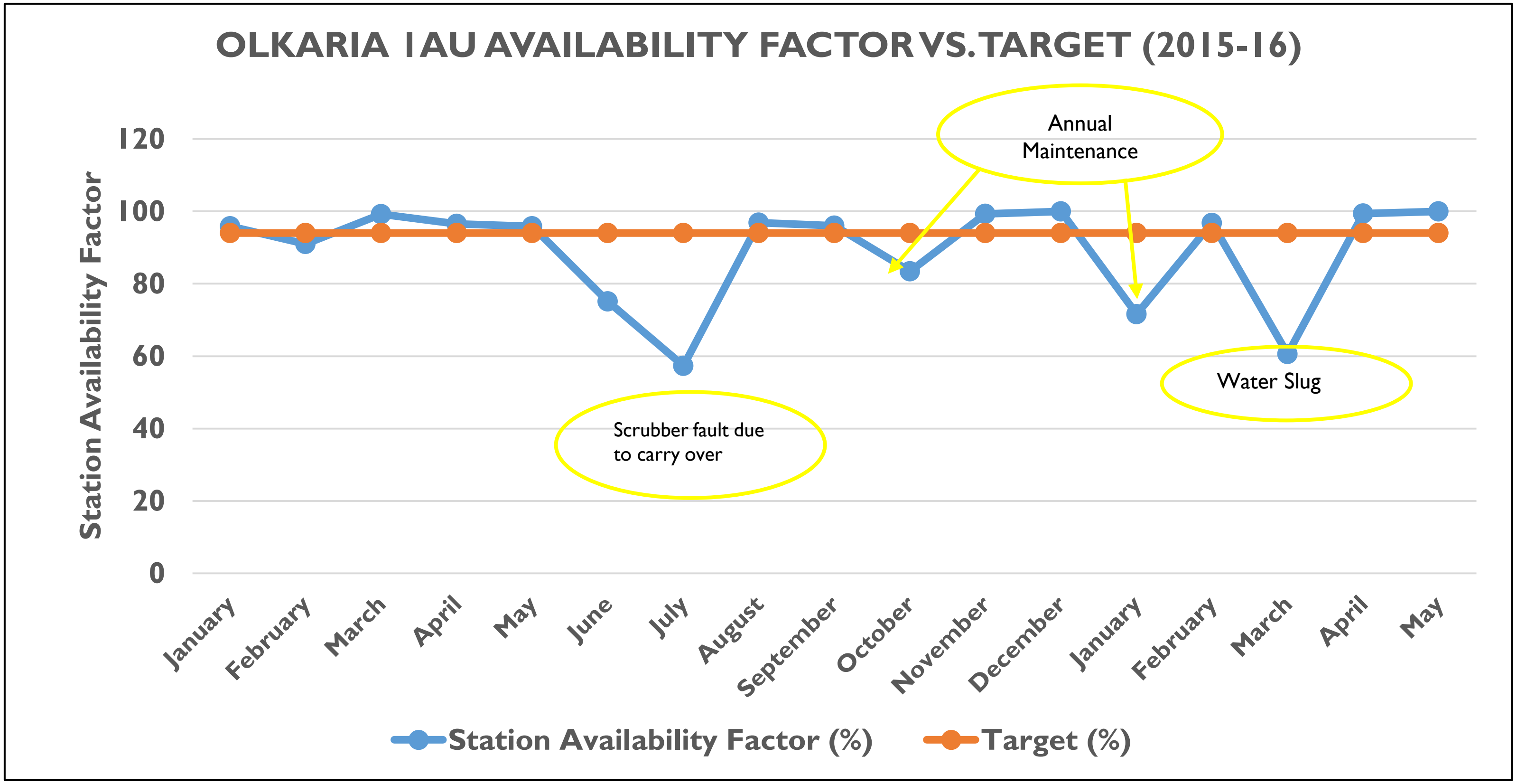
- The teams employ a mix of corrective and planned maintenance.

Steam Flow Diagram



CHALLENGES ENCOUNTERED

- Since commissioning,1AU has experienced maintenance issues ranging from *silica scaling* and *slug flow*. Other maintenance issues are GRP failure, damaged scrubber internals and cooling tower fills. These issues have affected plant efficiency thus *decline in overall plant availability* due to unwarranted stoppages considering that this is a *base load plant.*



Silica Scaling

Wells: Olkaria 1AU wells were tapped into a very high silica environment. This posed a silica scaling problem when the geothermal fluid came to the surface and pressure drops occurred. The well head pressures ranged between 6-9 barg while the separation pressures were 5.5 barg to give a turbine inlet pressure of 4.2 barg.

Vent Valves: The vent valves are ball butterfly (Fisher) type and are designed to handle a total of 1046 T/hr of steam. In January this year during annual inspection, the flow control valves and diffusers were found to be clogged after a very brief period of operation.

Steam Turbine: During commissioning, significant steam pressure drops between the 1st and 2nd stage steam turbine nozzles were experienced leading to onsite nozzle clearance enlargement by the OEM. At end of defect liability inspection, the turbine was disassembled and scaling found in the 1st stage nozzles. This was attributed to the unreceptive hot reinjection Well 13 leading to carry over from the separators into the plant.

Scrubber: Cyclonic type. Frequent drain valve clogging due to carry over initiated turbine trips. Later, the scrubber developed internal abnormal noises leading to cracks in the vortex tube and smoothing sleeve weld seam.

Slug Flow

<u>Steam Pipework:</u> In March 2016, Unit 4 main steam line pipes were found to be deflected. This was attributed to clogged drain valves.

Others

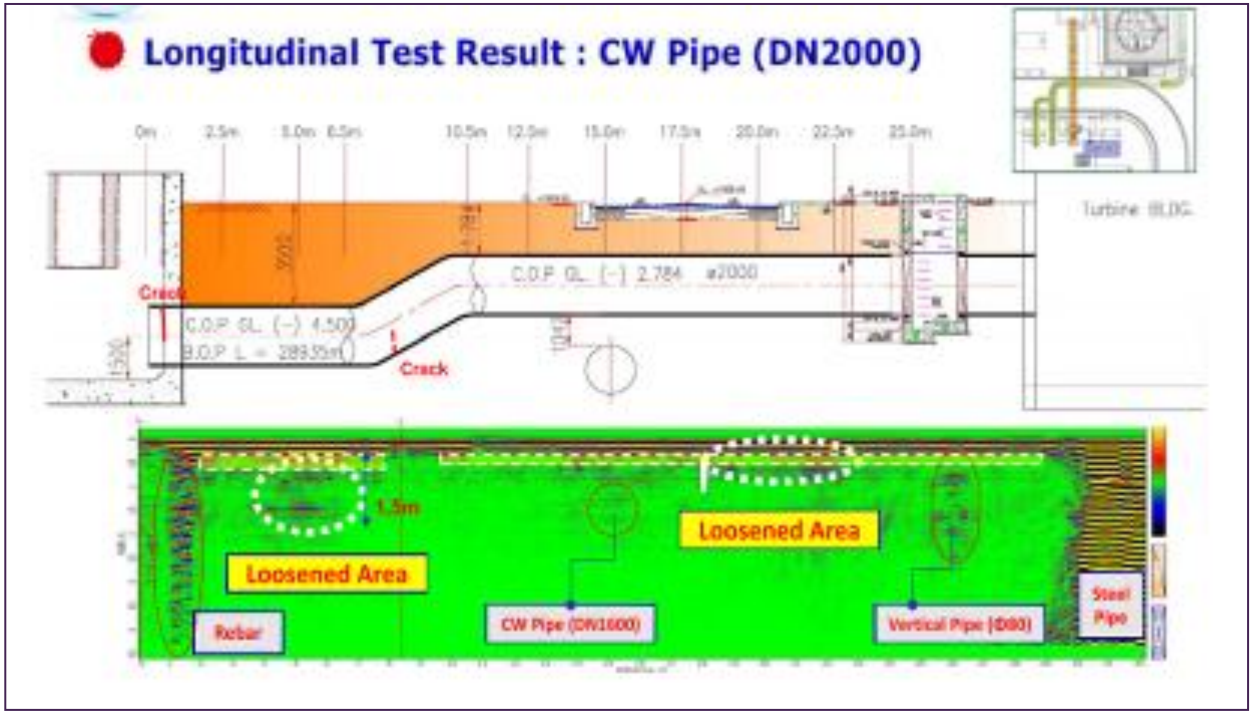
Glass Reinforced Polyester Pipes : it is used in the outdoor CWS. GRP is preferred because it is high corrosion and abrasion resistant, has a leak tight system for maximum loss free flow and also is cheaper compared to stainless steel. *The 2000mm GRP return pipe from Unit 5 cooling tower to condenser developed cracks which was noted after water from a faulty scrubber drain sipped into the hotwell pit area.* The GRP pipe sand bedding was washed out causing pipe differential settlement.

Cooling Tower Film Fills: The internals are film fills designed for a maximum TSS <150ppm. During annual inspection, the films fills were disintegrated as there were many loose sheets, large holes in the pack randomly distributed throughout the cells due to failure of the adhesive that binds each individual sheet into blocks.

SOLUTIONS OFFERED

Pressure Let Down Station: PLDS was installed between 29th May and 14th June 2015 so as to operate the wells at high pressures i.e. wellhead pressures of 10-14barg and separating at 10barg. It was preferred because at the time, it was *least cost intensive* and would be used on a temporary basis as other options are considered in future. Maintenance is mainly carried out on stuck pressure control valves.

GRP : To ascertain the effect of the leakage on the general area, *Geophysical surveys, ground penetration and electrical resistivity tests* were done. These tests confirmed *poor consolidation* as a result of the water ingress and grout injection was the available remedy for reinforcement of the sand bedding of pipe and the general area. This was done using low pressurized mortar. KenGen is considering encasing the GRP pipes in concrete and in other areas, using stainless steel pipes in ducts.



Recently, we had leakage of circulating water in Unit 4 1100mm & 1600mm GRP. Further investigation indicated poor compaction during construction. The pipes cracks were laminated.

Steam Turbine: The OEM disassembled the 1^{st} stage nozzles and modified them on site.

Main Steam Line : So as to ensure continuous operation, the Steam field team carries out *weekly routine checks*. The deflected pipe work at the power station was repaired and reinforced. To avoid such scenarios in future, it was resolved and documented that *frequent monitoring of clogged steam drains* must be undertaken so as to unblock them before starting up the plant.

Wells: Maintenance of these wells is majorly done on master, working and side valves. To prevent catastrophic failures, they are stroked, greased and gland packings replaced. The unreceptive well was water *quenched* and an additional brine line connected.

Valves: The valves are frequently stroked and calibrated while condensate drain ports and diffusers unblocked and cleaned.

Cooling Tower Fills: The supplied fills are currently being replaced with the required thickness. This was considered a failure in specification conformance.

CONCLUSION

- Running a geothermal power plant is easy. *To enable continuous operations, systems have been put in place such as SAP PM and DCS*. The team involved ensures best Engineering Practice in Operations and Maintenance.

- The plant was designed and constructed in a manner that facilitates routine, periodic and forced outage maintenance. This includes adequate provision of facilities such as equipment withdrawal spaces, access ladders, stairs and platform, crane access and lifting point and lay down areas. Isolating facilities are also provided to allow the safe and efficient maintenance of all items of the power plant.

THE END