GEOTHERMAL ENERGY DEVELOPMENT IN UGANDA - A COUNTRY UPDATE 2016

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Country Overview

- Area 241,000 km².
- Over 34 million people.
- Economy depends mainly on agriculture.
- Oil products imported (100%).
- Biomass represents 84% of the national energy balance.
- Geothermal Energy to contribute 1,500 MW to the energy mix.
Status of power supply in Uganda

- Installed capacity for electricity generation over 892.7 MW.
- The current power generation capacity is 724 MW (hydro, thermal, cogeneration).
- Peak Demand is about 580 MW.
- Electricity coverage is 18% for the whole country and 7% for rural areas.
- Annual demand for electricity is growing at about 8% per year.
Plan for increased power supply in the Short to Medium term (2015 – 2025)

- Increasing generation capacity using fossil fuels.

- Construction of two large hydropower dams, Karuma (600 MW) and Isimba (183 MW) to be completed in 2018.

- Enhancement of renewable energy development.

- Development of Geothermal (100 MW).

- Emplacement of energy efficiency measures.
Long-term measures (2025-2040)

- The development of large hydro power sites, namely, Ayago (840 MW), Oriang (392 MW).
- Interconnection of the regional power grid.
- Use of locally produced oil to generate thermal power (750 MW).
- Use of new and renewable sources of energy which include; solar, wind, biomass, peat and geothermal.
- Development of the country’s geothermal resources estimated at 1,500 MW.
- Development and use of nuclear energy.
Policy and Institutional Framework

- Renewable Energy 2007:
  - Introduced the feed-in tariffs (Geothermal 7.70 cents/KWh).
  - Standardized Power Purchase Agreements.
  - Obligation of fossils fuel companies to mix products with biofuels up to 20%.
  - Tax incentives on renewable energy technologies.

- Uganda has formulated a Geothermal Policy and Legislation which are pending approval by Cabinet and Parliament.

- Institutional framework:
  - A Geothermal Resources Department to explore and promote geothermal energy development.
  - Electricity Regulatory Authority (ERA) provides a generation license for all energy resources.
The aim is to develop geothermal energy to complement hydro and other sources of power to meet the energy demand of Uganda in sound environment.
Location of geothermal resources
The four major geothermal areas under study are Katwe-Kikorongo, Buranga, Kibiro and Panyimur located in the Western Branch of the East African Rift System and along the Democratic Republic of Congo (DRC).
Katwe: Geology

- The Geology is dominated by explosion craters, ejected pyroclastics, tuffs with abundant granite and gneissic rocks from basement.
- Lava flows in L. Kitagata and Kyemengo craters.
- Extinct hydrothermal deposits in and around L. Katwe and L. Kikorongo.
- Surficial deposits (Rift valley sediments).
- Gneisses in the Rwenzori Mountains.
The geothermal surface manifestations in the Katwe prospect are hot springs located in the Lake Kitagata crater, and warm springs in Lake Katwe.

The maximum surface temperature is 70°C in Lake Kitagata, while in Lake Katwe Crater it is 32°C.

The geothermal fluids are characterized by high carbonate and sulphate, and salinity of 19,000 - 28,000 mg/kg total dissolved solids.

The Subsurface temperature is estimated at 140-200°C (Armannsson, 1994). High concentration of hydrogen sulphide at 30-40 ppm suggests its source could be volcanic and hydrothermal (Bahati, 2003).
Katwe: Geophysics (TEM) results

- Low resistivity Anomalous Areas mapped by geophysics (TEM).
- Drilling of shallow boreholes (200 – 300m) at selected sites.
- Temperature gradient drilling and measurements at Katwe (13 - 36°C/km) suggest geothermal reservoirs that are either deep seated or offset from the drilled areas.

Katwe resistivity anomalous areas
Kibiro: Geology

- East of the escarpment the geology is dominated by the ancient crystalline basement (granite and gneisses), block faulted, extensive deposition of travertine.

- West of the escarpment; Rift Valley sediments of up to 4-5 km thick.
**Kibiro: Geochemistry**

- Subsurface temperatures 150-250°C predicted by geothermometry and mixing models.
- Salinity up to 4,000 – 5,000 ppm.
- Geothermal water has a cold water component and hydrocarbons.
- The fluid is depleted in sulphate (20-50 ppm): interaction of sulphate with hydrocarbons to produce hydrogen sulphide.
- Recharge is from high ground in Mukihani-Waisembe Ridge.
Kibiro: Geophysics (MT) results

- All the cross-sections show the clay alteration deepening towards the lake but vary to the extent that they indicate a clay apron that might overlie a thermal aquifer.

- Low resistivity sediments in yellow-red, high resistivity Pre-Cambrian is blue.
Kibiro: Geophysics (TEM) results

- The objective of TEM was to identify a relatively shallow onshore capped aquifer that might host a >150°C geothermal aquifer that could be tested at low cost, and to collect a telluric shift in MT.
- The Figure shows a cap rock which appears to be thicker and less distinctly layered than the MT inversion.
- The clay zone (yellow-red) is interpreted as capping a more resistive and possibly permeable hot aquifer or reservoir.
Kibiro: Proposed subsurface conceptual model

- The 240°C reservoir hosting the geothermal liquid is assumed to be situated below the lacustrine sediments at depths of 2.0 to 2.3 km.
- A temperature of 150°C is attained through mixing between the uprising geothermal liquid and the descending cold brackish water establishing a secondary reservoir.
- Conductive cooling occurs afterwards during the final upflow of the mixed water to the surface.

Seismic cross-section (Karp et al., 2012) on which the possible geothermal reservoir and paths of the geothermal liquids are indicated.
Kibiro: Recommendations

- Drill shallow wells (about 200 to 300 m depth) to explore the possibility that a shallow aquifer exists, as hinted by the resistivity (MT/TEM) data.
- If the temperatures are closer to 140 to 150°C, then design a low temperature exploration plan for the discovered resource.
- If it shows more definitive indications of being over 230°C, then consider options to target the deeper system, possibly by directional drilling.
Buranga: Location and geology

- Located at the foot of the Rwenzori Mountains.
- Sedimentary environment.
- No evidence of volcanism but highly tectonically active.
- Most impressive geothermal manifestations in the whole Western Branch of the EARS.
- Surface temp. 98°C.
Buranga: Geothermal surface manifestations

1. Boiling hot springs
2. Close to boiling
3. Gas discharge
4. Geothermal grass
• Subsurface temperatures of 120-150°C have been predicted by geothermometry.
• Fluids with neutral pH (7-8).
• Salinity 14,000-15,000 mg/kg TDS.
• The source of sulphate: sulphate reach minerals/rocks.
• Recharge is from high ground in the Rwenzori Mountains.
Buranga: Seismic results

- Micro-seismic surveys located a subsurface anomaly within the vicinity of the thermal activity at Buranga and could be the sources of heat for the area.

Buranga conceptual model (DGSM-BGR 2007)
Buranga: MT/TEM Results

- The sedimentary basin highly conductive due to the clay type minerals which are consolidated in the sediments.
- The conductive layers have been mapped and can go deeper than 3000 m b.s.l.
- The Figure shows a 2D MT resistivity map at 1500 m b.s.l.
- The conductive anomalous area is more prominent in the NNE – SSW direction implying that it is possibly controlled by the Bwamba fault.
Buranga: Cross-section through MT anomalies

- Low resistivity layer close to the surface underlain by a high resistive layer.
- The low resistive layer could represent a cap rock made by highly conductive clay minerals.
- Beneath would lie a geothermal reservoir which is expected to be highly resistive.
- The model looks ambiguous because a few soundings done and a need to collect more data at a close spacing.
Panyimur: Geochemistry

- Geothermal manifestations are hot springs namely Amoropii, Okumu and Avuka with surface temperatures of 60, 47, and 45°C respectively.
- Other surface manifestations are altered ground, geothermal grass and shrub trees.
- High levels of hydrogen sulphide gas (10 – 12 ppm) suggest that the source of heat could be magmatic.
Panyimur: Magnetics and Gravity results

Both Gravity and Magnetic data show possible geothermal signatures. Magmatic intrusions have high density hence Gravity -High and heat demagnetises the rocks hence low magnetic anomaly for geothermal is detected as magnetic -Low.
Panyimur: Recent MT Results

MT – Cross-section

MT: 2D
## Status of Licensing geothermal areas

<table>
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<tr>
<th>S/No</th>
<th>Area</th>
<th>License Holder</th>
<th>EL</th>
<th>Date of Issue</th>
<th>Date of Expiry</th>
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<td>2.</td>
<td>Katwe-Bunyampaka</td>
<td>AAE Systems Inc.</td>
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<td>6.</td>
<td>Ntoroko</td>
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</tbody>
</table>
Current Support to Government of Uganda

- African Rift Geothermal Development Facility (ARGeo).
- Climate Technology Centre Network (CTCN) of the United Nations Framework Convention on Climate Change (UNFCCC).
- UK Department for International Development (DFID) funded East Africa Geothermal Energy Facility (EAGER) represented by Adam Smith International (ASI).
- MoU between Government of Uganda and Toshiba.
- Energy for Rural Transformation (ERT III) Funded by WB.
- Fluids and Volatiles Laboratory, Scripps Institution of Oceanography, University of California San Diego (UCSD).
Challenges

- Inadequate Policy and Legal framework.
- Inadequate data on the geothermal resources.
- Inadequate resources for exploration and feasibility study.

Capacity building:
  - Inadequate trained personnel to carry out exploration and development of the geothermal resources.
  - Inadequate equipment.

Private sector participation in surface exploration has led to speculation than development.
Strategies to address the challenges

- **Institution Framework**: Creation of a Geothermal Department to handle activities regarding geothermal development.

- **Policy and regulatory framework**: Review the existing policy and legal framework, and put in place a new geothermal policy and legislation to focus on geothermal energy development.

- **Financing of the Geothermal Energy projects**: Government to provide funding for geothermal exploration and development.

- **Feed-in tariffs**: Government to establish Feed-in tariff to create a predictable business environment for geothermal energy projects.
Conclusions

- Potential for geothermal development.
- Government commitment to develop geothermal resources.
- Subsurface temperatures in the range of 100 - 250°C suitable for power generation and use in industry and agriculture.
- Surface exploration near completion at Kibiro and Panyimur.
- Private sector not performing to expectations.
Recommendations

- Fast track the Formulation of Geothermal Policy and Legislation.
- Need to finalize surface studies at Katwe, Buranga, Kibiro and Panyimur & proceed to the feasibility study.
- Detailed studies of other geothermal areas in Uganda.
- Capacity building (manpower and equipment).
Uganda geothermal in pictures

Thank You