Geothermal Potential of East Africa - How to Realise it.

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Sustainable Development Goals Short Course IV on Exploration and Development of Geothermal Resources
Learning Objectives

• Understand the existing geothermal potential in the East Africa Rift System.

• Understand the various ways to realising the geothermal potential of East Africa region.
Outline

- EARS- Overview
- Geothermal Potential in the EARS
- Barriers to Geothermal Development
- Ways to realise Geothermal Potential in the Region
East African Rift System-Overview

- Extends from Red Sea to Mozambique in the south.
- Geothermal potential > 20,000 MWe- largely untapped.
- Two rifting trends- Eastern & Western branches.
- Eastern branch- older & volcanically active.
- Western branch- younger, less active.
- Magmatism along EARS-given rise to geothermal activity.
- Hydrothermal activity- fumaroles, hot springs, hot & altered grounds, geysers, sulphur deposit, etc.
Eastern branch of EARS.

- Extends for >4000 km.
- Comprises Afar, Ethiopian & Kenya rifts.
- Characterised by numerous Quaternary volcanoes-shallow magmatic bodies.
- Volcanic activity commenced about 30-45 Ma.
Geothermal potential in Kenya

- Geothermal potential > 10,000 MWe.
- Geothermal systems- KRV.
- 13 High temp. along the KRV.
- Mostly associated with Quaternary volcanos.
- Geothermal development- 1952.
- Aggregate installed capacity- about 865 MWe.
- 6 power plants & 15 Wellhead generating units in Olkaria.
- 1 wellhead generating unit in Eburru.
- Several direct use applications.
### Summary of geothermal power plants

<table>
<thead>
<tr>
<th>Power Plant</th>
<th>Output (MWe)</th>
<th>Year Commissioned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olkaria I (Old unit)</td>
<td>45</td>
<td>1981-1983</td>
</tr>
<tr>
<td>Olkaria I (Additional units)</td>
<td>150</td>
<td>2015</td>
</tr>
<tr>
<td>Olkaria II</td>
<td>105</td>
<td>2003-2010</td>
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<tr>
<td>Olkaria III (Orpower 4 Inc.)</td>
<td>155</td>
<td>200-2018</td>
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<tr>
<td>Olkaria IV</td>
<td>150</td>
<td>2014</td>
</tr>
<tr>
<td>Olkaria V</td>
<td>165</td>
<td>2019</td>
</tr>
<tr>
<td>Olkaria Wellhead units</td>
<td>81.1</td>
<td>2012-2016</td>
</tr>
<tr>
<td>Eburru wellhead unit</td>
<td>2.5</td>
<td>2012</td>
</tr>
<tr>
<td>Oserian</td>
<td>4.3</td>
<td>2004-2006</td>
</tr>
</tbody>
</table>
Wellhead Technology

- Fast-track utilisation of steam from production wells before conventional power plants.
- Short time to install (6 months); conventional power plants: 24-36 months.
- KenGen PLC pioneer in WHT.
- Total- 16 WH generating units.
- Total output- 83.5 MWe.
  ✓ Reduction of time to market.
  ✓ Maximum utilization of available steam.
  ✓ Shorter and higher ROI on wells.
  ✓ Flexibility.
  ✓ Cost effective.
New Energy Act 2019

- Part IV provides for development of Renewable Energy with special attention on geothermal resources.
- Establishments of inter-ministerial Renewable Energy Resource Advisory Committee (RERAC).
- Geothermal Licence granted in an open, competitive & transparent manner.
- Licensee cannot transfer the license to a third party without the consent of the CS.
- Forfeiture of dormant geothermal licenses.
- Establishment of Renewable Energy feed-in-tariff system.
Recent and Planned Activities

• Develop 5000 MWe by 2030.
• 4000 MWe from expansion of Olkaria, Eburu & Menengai geothermal fields.
• Additional generation from IPPS- licensed to various geothermal prospects.
• Drilling on-going in Paka.
• Construction of Olkaria 1 AU unit 6- on-going
• Upgrade of Olkaria 1 (Old power plant) to 50 MWe- Tendered.
Geothermal Potential in Ethiopia

- Geothermal systems confined to ERS.
- Geothermal potential: 10,000 MWe.
- 12 high temp. geothermal systems along ERS.
- 8 wells drilled in Aluto- depth 2500 m.
- 4 productive with reservoir temp. 350 °C.
- Bottom-hole temperature 300 °C.
Recent and Planned Activities

• Geothermal Master Plan study in the ERS-assistance from JICA.
• New Geothermal Law enacted & operationalized in 2016 (Geothermal Resource Development Proclamation) - opened doors to IPPs.
• Medium term plan- 675 MWe by 2025.
• Long term plan- 5000 MWe by 2037.
• Drilling in Aluto-Langano- awarded to KenGen PLC & Shandong Kerui.
• Drilling in Tulu Moye geothermal prospect- KenGen PLC.
Geothermal Potential in Djibouti

- Lies at the Afar triple junction.
- Geothermal prospects located in Asal & Hanle Rifts in Afar depression.
- Geothermal potential- 230-860 MWe.
- Geothermal exploration commenced in 1970.
- 6 exploratory wells drilled in Asal geothermal field & 2 in Hanle geothermal field between 1975-1989.
- Wells characterised by limited permeability & hypersaline geothermal fluids.
Fiale Wells
Recent Activities

- Successful drilling of 3 directional exploratory wells in Fiale caldera.
- Fiale-1 (NE), 2 (SSW) & 3 (SW) to depths of around 2500-2750 m (TVD).
- Well completion reports compilation on-going.
Geothermal Potential in Eritrea

- Two main geothermal prospects: Alid & Nabbro-Dubbi.
- Both located within the Danakil depression.
- More studies have concentrated in Alid volcanic center.
- Detailed geoscientific investigations revealed reservoir temperature of 250 °C.
Geothermal Potential in Tanzania

- Estimated geothermal potential > 5000 MWe.
- Prospects located on both the Eastern & Western arms of EARS.
- Geothermal exploration- 1949.
- Studies indicated presence of high, intermediate & low temp. systems in northern & southern Tanzania.
- 4 prospect prioritized- Ngozi, Songwe, Kiejo-Mbaka & Luhoi.
- Exploration drilling (slim-hole) in Ngozi planned for late 2019/early 2020 by TGDC.
Geothermal Prospects in Tanzania

SDG Short Course IV on Exploration and Development of Geothermal Resources
Organized by UNU-GTP and KenGen | Lake Bogoria and Lake Naivasha | Nov 14-4 Dec, 2019
Recent and Planned Activities

• Establishment of TGDC in 2013.
• Formulating regulatory & legal framework to govern geothermal development - previously no policy guiding development of geothermal resources.
• Medium term plan - 200 MWe by 2025.
• Development of TGDC 25 years Strategic & Business Plan.
• Fund mobilization for exploratory drilling & environmental studies- Government of Tanzania & GRMF.
Geothermal Potential in Uganda

- Geothermal potential areas associated with the Western branch of EARS.
- Four major geothermal areas: Katwe-Kikorongo, Buranga, Kibiro & Panyimur.
- Geothermal exploration - 1950s.
- Estimated potential - 1500 MWe.
- Hot springs & fumaroles are predominant surface thermal manifestations.
Recent and Planned Activities

• Commitment to carry out detailed geo-scientific studies of the prospects- Uganda Geothermal Resources Development.
• GEOTHERM program sponsored by the Government of Germany- detailed studies of Buranga prospect.
• Initiation of institutional framework- led to formation of Geothermal Resource Department.
• Partnering with various international organizations to speed up development of geothermal resources- e.g. ARGeo, CTCN, UNFCCC, DFID, etc.
Geothermal Potential in Rwanda

- Geothermal potential estimated at between 170-300 MWe.
- Prospects located along the western border of the Western branch.
- Include- Gisenyi, Karisimbi, Kinigi & Mashyuza.
- Preliminary assessment carried out in Gisenyi & Mashyuza.
- Established hot springs measuring - 54-74 °C.
- Two exploration wells drilled in Karisimbi in 2013.
- KW-01 & KW-03 to 3015 m & 1367 m depth, respectively.
- Alteration mineralogy & measured temp. demonstrated non-existence of a geothermal reservoir.
Surface Thermal Activity at Gisenyi

- Defined by One Hot Spring on Lakeshore
  - 70-75 °C
  - 2-5 kg/s Flow Rate
  - Dilute Na-HCO₃ Chemistry
  - Minor Silicification in Brecciated Quartzite
- Evidence of older travertine deposits along shoreline
- Proximity to Virunga Volcanics
  - Possible distal outflow from higher temperature system
Recent and Planned Activities

• Development of detailed Geothermal Strategy & Geothermal Act.
• Inclusion of private sector involvement in geothermal exploration & development.
Geothermal Potential in Zambia

- Geothermal systems associated with the south-western branch of the Western rift.
- Two main prospects - Kapisya & Chinyunyu.
- Circulation of springs common along fault zones.
- Hos springs in Kapisya discharge at 85 °C, at Chinyunyu discharge at 60 °C.
- A mini geothermal pilot power plant- 200 Kw- at Kapisya hot springs- funded by Italian government in 1987.
- Studies by KenGen & ZESCO revealed that each prospect can generate 2 MWe using Binary technology.
Recent and Planned Activities

- Completion of drilling of 8 TGH by Kalahari GeoEnergy (an IPP) at Bweengwa River Geothermal Resource Area.
- Prospect situated in Kafue Trough.
- Drilled depths not mentioned.
- If successful- full technical & commercial feasibility study in late 2019.
- Surface manifestations in the areas- largely geothermal springs.
Geothermal Potential in Comoros

- Geothermal potential estimated at > 40 MWe.
- Potential areas include Grand Comore Island, La Soufriere, Karthala & La Grille volcanoes.
- Geothermal potential highest within the Grand Comore Island.
- Phase one goal- 10 MWe.
- Thermal activity emplaced along fractured basaltic lava flows.
- Gas geothermometers indicate reservoir temp. of around 300 °C.
Geothermal Potential in Mauritius

- Volcanic activity- 0.03-8 Ma.
- Volcanism of Mauritius and nearby Reunion fed by same magmatic source.
- Research projects in La Reunion_200 °C at 2100 m.
- Activity of Mauritius at present-quiescent.
- Volcanism- fed by deep seated magma chamber.
- Technical literature-caldera structure in the central island.
Geothermal Potential in Nigeria

- Geology - Sedimentary basins & Basement complex rocks.
- Products of magmatic & volcanic activities - Benue trough.
- Manifestation - warm springs.
- Warm springs - Ikogosi, Kerang, Ngeji, Wikki, Rafin Rewa.
- Temperature range - 32-54 °C.
- Ikogosi warm spring - tourist attraction and a swimming pool.
Geothermal Potential in Morocco

• First studies 1968- ME&M.
• Later studies university researchers.
• Most promising zone NE province & sedimentary basins of Sahara.
• Liasic reservoir- most important geothermal aquifer.
• Feeds > 24 thermal manifestations (26-54 °C).
• Warm springs_bathing, tourism and washing.
Barriers to Geothermal Development

• Financial challenges.

• Technological & Human capacity challenges.

• Environmental & Socio-economic challenges.

• Legislative & Policy challenges.
Ways to realise geothermal potential

• Formulation of geothermal energy policy & legislative framework.
  ✓ Clear policies & legal framework to increase investors interest.
  ✓ Creates an environment for investment by both Government and IPPs.
  ✓ Provides for Governance structure.
  ✓ Provide for both direct and indirect uses of geothermal energy.
  ✓ PPA enhancement.
A case example for Kenya
Institutional Setup

Establishment of Special Purpose vehicle;

✓ Geothermal Development Company- Kenya.

✓ Tanzania Geothermal Development Company- TGDC.

✓ Office Djiboutien de Développement de l'Energie Géothermique (ODDEG)- Djibouti.

✓ Creation of Geothermal Departments in Government Ministries e.g Kenya- Department of Geothermal Exploration, Ministry of Energy.
Establishment of partnerships- sound MoUs

- Government to Government- Ministry of Energy (Kenya) and Ministry of Energy (Djibouti).

- Institution to Institution- e.g TGDC and GDC.

- KenGen working on an MoU with ODDEG of Djibouti.

- Technical assistance at short notice- Avoid bureaucratic procurement rules.

- Capacity building- Local and international, e.g UNU- GTP, KENGEN- has over a longtime supported geothermal development through training & consultancies.

- KenGen sends at least 5 Scientists/ engineers for 6 months Geothermal technology course. Others on Masters and PhD.
Strengthening of ARGeo

- **Member countries**: Eritrea, Ethiopia, Kenya, Rwanda, Tanzania, Uganda, Djibouti, Burundi, DRC, Zambia, Comoros.

- Promotion of geothermal among member countries.

- **Capacity building support to member countries**: AGCE. Governments and Organisations to support the Africa Geothermal Centre of Excellence.

- Grants for surface exploration and equipment.

- Promotion of exploration, appraisal & production drilling to mitigate the geological risk.

- Soliciting financial and technical support for member countries- aimed at establishing a regional geothermal resource network for assistance in geothermal development.
Adequate Government Funding

✓ Government financing;
  • Surface studies and exploration drilling or
  • Surface studies to reservoir management

✓ Raising funds for Public Listed companies through stock exchange- privatization.
Strengthening of GRMF

- Geothermal risk mitigation fund - 40% grant for exploration drilling (up to 3 wells).

- 80% support to Geo-scientific studies.

- 20% support to Infrastructural works.

- GRMF encourage public & private sector participation in geothermal development.

- Burundi ▶ Comoros ▶ Djibouti ▶ DRC ▶ Eritrea ▶ Ethiopia
  ▶ Kenya ▶ Rwanda ▶ Tanzania ▶ Uganda and ▶ Zambia
Creation & Strengthening of AGCE

✓ Train manpower to handle the massive geothermal resources in the region.
✓ Offer local training at an affordable cost.
✓ Will result to immense savings on training budget.
Supporting NZ-AGF

✓ Target countries - those with geothermal potential in East Africa nations & eligible for GRMF funding.

✓ For Technical Assistance (Capacity building).

✓ Overall goal - expand access to affordable, reliable & clean energy in East Africa nations through increased use of geothermal energy resources.
Stakeholder Management

✓ Stakeholder mapping.
✓ Olkaria Geothermal field - large part is in the Hell’s Gate National Park
  • MoUs
✓ Eburru Geothermal field - Kenya Forest Service - MoU.
✓ During projects development - Stakeholder coordination committee.
✓ Creates early personal relationships with project owners.
Geothermal Associations

✓ To push for geothermal awareness in countries-e.g. GAK, GAE.

✓ Create presence.

✓ Advocate for geothermal policies, laws and regulations.

✓ Bring together professionals to advance interests.

• Enhance professionalism.
Promoting technological development/innovation

✓ Good and well established technologies can be used, e.g;
• Innovative modular power plant technology in Olkaria, Kenya.
• Direct use applications e.g. Olkaria geothermal spa & demonstration centre.
• Pilot agricultural direct use in Menengai, Kenya.
• Application of binary technology for low-medium enthalpy resources.
✓ Innovation- for example by establishing similar forum such as KenGen’s annual G2G Innovation seminar.
Build network of competence thro’ collaborations

✓ Currently the knowledge of geothermal development is limited to a few countries, specifically Kenya.
✓ To spread the expertise and on geothermal energy & raise awareness of its potential;
  • Networks and know-how transfer need to be strengthened.
  • Implies not only of knowledge.
✓ Collaborations can be;
  • Institutions based.
  • Organisations’ based.
Conclusion

• Magmatism along the EARS has given rise to the current geothermal activity.
• Presently, only Kenya & Ethiopia have developed geothermal resources.
• Both Public & Private sector participation is key to accelerating development of geothermal resources in the region.
• Direct use application of low-temp. geothermal resources should be encouraged in the region.
• Formulation of sound Geothermal development policies and government support is key to overcoming some barriers to geothermal development.
THE END

THANK YOU
INFORMATION

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