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Fact sheet for geothermal development to promote Public Private Partnerships in East Africa

Uganda

Overview of electricity sector status

The total power generation in Uganda was 1346.6 MW by 2021. The largest share came from hydro at 1,072.9 MW equivalent to 79.9% of total generation. Thermal plants contributed to 8.2% and finally bagasse at 7.5% (Uganda Energy Regulatory Authority Portal). Figure 1 shows grid-connected installed electricity capacity trends in Uganda by source start from 2012 to 2021. Total grid-connected electricity capacity has risen from 718 MW to 1,259 MW, and renewable energy percentage has also increased 10% from 2012 to 2021. Electricity generation is mainly through hydropower which puts the country in the bottleneck of over-dependence on one source of energy.

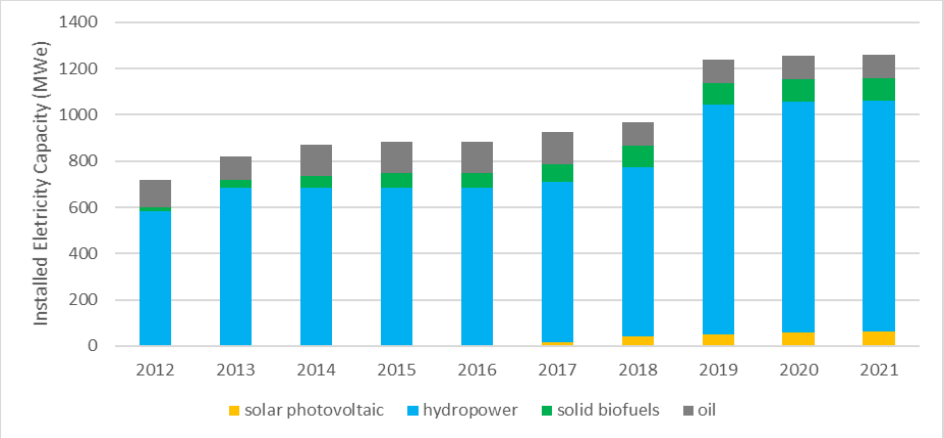

Figure 1: Grid-connected installed electricity capacity trends in Uganda by source

Data Source: (IRENA, 2022)

As shown in Figure 2, electricity generation in Uganda has been increasing in the recent 10 years, of which hydropower accounted for 90% in 2019. Due to the reason that geothermal energy is still under development, electricity capacity and electricity generation of geothermal energy have not existed yet.

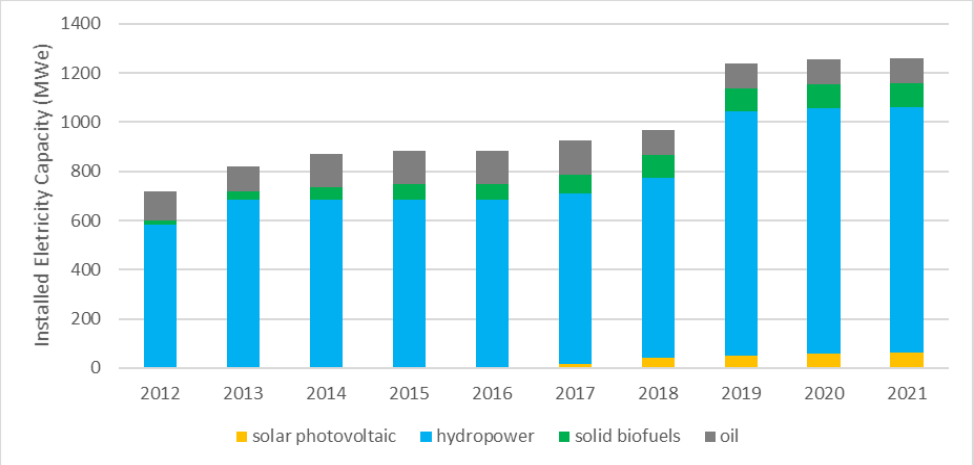

Figure 2: Grid-connected installed electricity capacity trends in Uganda by source

Data Source: (IRENA, 2021)

Electricity Access in Uganda

As of 2021 only 49% of Ugandans had access to electricity connection. Connectivity rate for the urban residents is at 90% while in the rural areas, the access rate is at 36%. The use of alternative sources of electricity is also higher in the western region (53%) and central (37%) regions than in the eastern (29%) and northern (31%) (Afrobarometer, 2021).

Power Generation Expansion Plan

In order to achieve sustainable energy production in Uganda, a target of 3,500 MW was proposed to be installed by 2025. This growth was planned to be driven largely from hydro power sources including Ayago 840 MW, Kiba 330 MW and Oriang' 392 MW and solar photovoltaic plants. Uganda has been exploring geothermal resources but viable projects are yet to be identified. The Government has also been contemplating about nuclear power generation.

Power Purchase Agreement/Feed-in-Tariff and Retail Electricity Tariff

The currently available power purchase agreement tariff for various power generation companies in Uganda are accessible from the portal of Uganda Energy Regulatory Authority published in 2018 (Uganda Energy Regulatory Authority, 2022). The tariffs for hydro power projects vary from 6.6 – 10.01 US$ cents/kWh while thermal plants (HFO) have a tariff of 17.89 – 19.96 US$ cents/kWh. Cogeneration power plants have a tariff of US$ cents 9.61 – 11.04/kWh.

Feed in tariff (FiT)

Uganda Electricity Transmission Company Limited is the body in charge of publishing standardized tariff for sales of renewable energy generated electricity to the grid. The maximum capacity to be fed to the grid from such sources is 20 MW. Other renewable energy technologies, excluding hydro and bagasse will not have a fixed generation capacity. However, other factors such as ceiling price and maximum return on equity are included in the tariff pricing (Uganda Energy Regulatory Authority, 2022).

Overview of geothermal development status

Geological setting

Geothermal prospects in Uganda are situated in the Western branch of the East African Rift System that runs for most of its length along the border of Uganda with the Democratic Republic of Congo (Figure 3). The Western Rift valley is marked by intense faulting, often accompanied by seismic activities. Exploration has been going on in the four most promising geothermal prospects, namely, Katwe-Kikorongo (Kasese), Buranga (Bundibugyo), Panyimur (Nebbi) and Kibiro (Hoima). The three areas were prioritized due to the presence of volcanoes in Katwe and strong geothermal manifestations at Buranga, Panyimur and Kibiro.

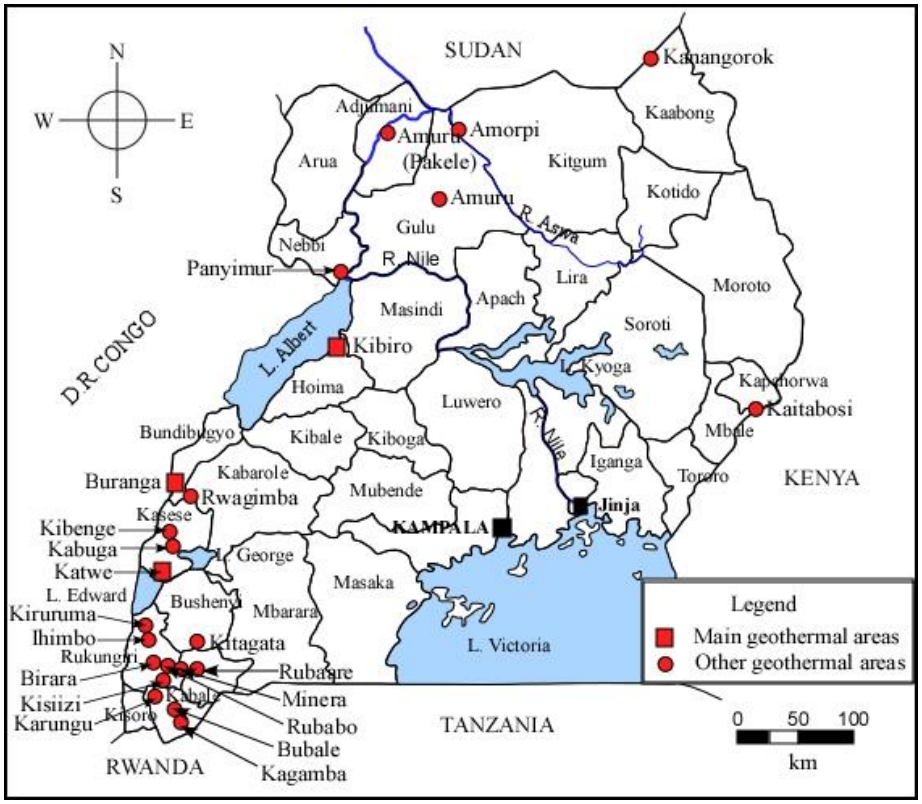

Figure 3: A map showing the location of the of the main geothermal prospects in Uganda (Bahati G., 2007)

Geothermal fields and prospects

- **Kibiro Geothermal prospect**

The Kibiro geothermal prospect lies along the main east bounding rift fault at the shores of Lake Albert (Figure 4). The prospect is located in Hoima District in western Uganda. Detailed geological mapping has been carried out in Kibiro since 2003 and which indicated the possible existence of a geothermal reservoir in the area and located within the fault zone (Gíslason, Árnason, & Eysteinsson, 2004). The area is characterized by deeply faulted Precambrian basement rock comprised of granites, gneisses and mylonitic units along the fault zone that dips west (Figure 4). To the west lies a thick accumulation of thick sequences of rift valley arenaceous Kaiso and argillaceous Kisegi sediments of at least 5.0 km thickness, but without any known volcanic rock occurrences on the surface (Bahati & Natukunda, 2008); Karp et al., 2012). The thick sediments have been successfully explored for oil and gas deposits. No oil and gas wells have been located within the Kibiro geothermal prospect. The faulting pattern in the area is characterized by two main directions, namely, N20°E and N90°E. Crosscutting joints striking mainly E-W and N20°E with vertical dips are found in all the rock types.

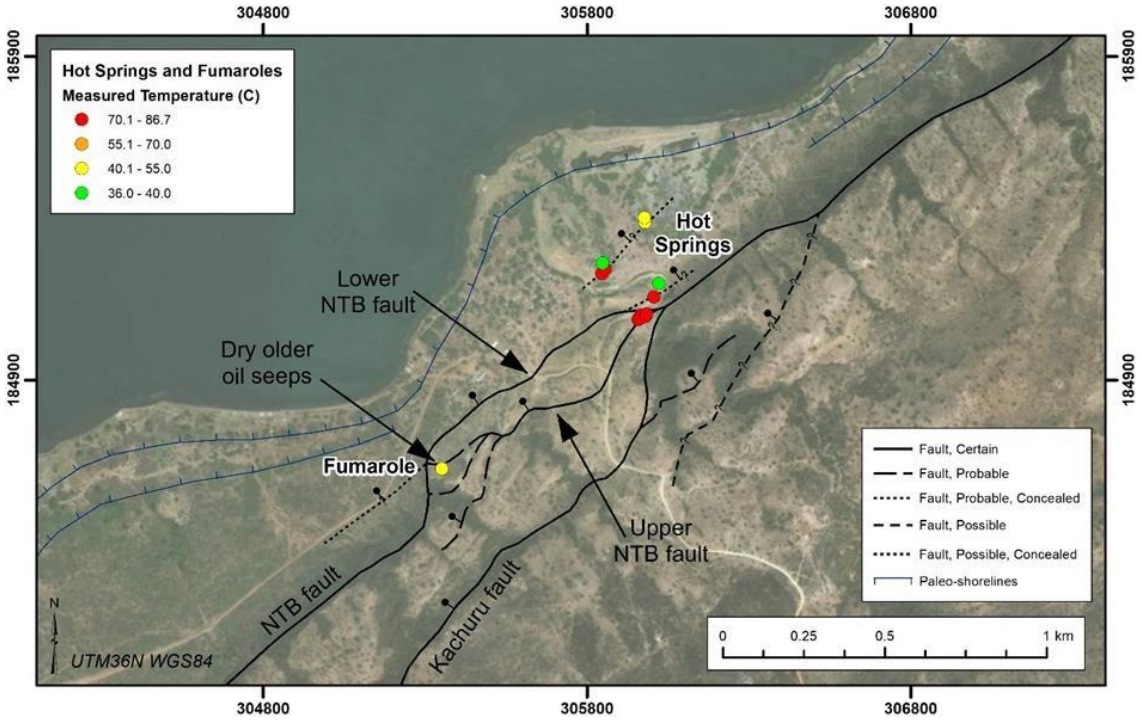

Figure 4: Kibiro structural geology and surface manifestations (EAGER – MEMD, 2019)

Geothermal manifestations are characterized by presence of hot springs along the fault zone (Figure 4 and 5). Some areas have sulphur deposits which seem to occur in association with fumaroles, hot springs, and oil seepages. The Kibiro prospect is controlled by the North Toro Bunyoro fault. Hot springs discharge at 86.4°C while the fumarole in the area has a maximum temperature of 45°C. The hot springs are highly saline with concentrations of up to 5,000 mg/kg and thus depositing large volumes of salt which is sold for domestic uses in the surroundings districts and for salt lick for cattle. Ministry of Energy and Mineral Development of Uganda undertook further exploration of Kibiro through temperature gradient hole drilling of eight holes to 200 - 300 m each. High temperatures gradient of 70-340°C/km was measured. Fluid geothermometry indicates that the reservoir is in the range of 150 - 250°C.

Figure 5: Photo showing the main rift border fault at Kibiro. Hot springs emanate from the foot of the escarpment to the right (From Bahati, personal communication 2023).

- **Buranga Geothermal Prospect**

Buranga is located at the western foot of the Rwenzori massif near the base of Bwamba escarpment and localized by the major rift faults. Buranga has no evidence of volcanism but is highly tectonically active. On the east side of the hot springs lies the Rwenzori massif while in the west, valley fill consisting of Kaiso beds and peneplain gravels of variable sands. The Kaiso sediments are underlain by Kisegi sediments. The rocks form the northern half of the Rwenzori massif and consist of mainly migmatites, gneisses and amphibolites. The main rift fault in this area strikes generally N45^{o}E and dips N60-65^{o}W. Other joints strike N10-30^{o}E and have complex joint systems. The hot springs lie on a fracture/fault line striking N40^{o}E and sympathetic to the main Bwamba rift fault.

In the whole of the western branch of the East African Rift System, Buranga has the most impressive surface thermal manifestations. They include hot springs, calcareous tufa and recent surveys have reported some fumarolic activity at the Mumbuga spring area (Figure 6). The springs are situated in a swamp in the tropical rain forest a few hundred meters westerly of the Bwamba fault, which forms the western flank of the Rwenzori. The Buranga hot springs consist of 37 springs with an overall flow rate of 30 l/s and temperatures up to 98.4°C (Ochmann, Lindenfeld, Barbirye, & Stadtler, 2007). Deposits of sulphur have been reported at some locations within the Buranga geothermal prospect. Geothermometry using fluid and isotope techniques reveal a fault-controlled, medium temperature system at about 150^{o}C. The geothermal power potential at Buranga estimated based on current knowledge, extent of the geothermal manifestations, moderate geothermometric temperatures and large volume of hot water discharged, can support generation of few to tens of megawatts of electricity.

Figure 6: Photo showing the Buranga (Nyansimbe) hot spring. Rwenzori Mountain in the background

- **Katwe Geothermal Prospect**

The Greater Katwe geothermal prospect stretches from Lake Katwe to Lake Kikorongo and occupies an area of approximately 150 km^2. Geology of Katwe geothermal prospect is dominated by volcanic explosion craters with pyroclastic ejecta composed of tuffs and lithics of granite, ultramafics, and gneisses. Minor occurrences of lava are found in Lake Kitagata and Kyemengo craters. The Katwe volcanic rocks are dominantly potassic akin to the rocks of the Virunga volcanic province. Such magma types have been postulated to originate from metasomatised lithospheric mantle (Rogers, James, Kelley, & Mulder, 1998). Outside the crater, the geology is characterized by surficial deposits to the east and the west, and in the north is the Rwenzori Mountains whose geology is dominated by gneisses, granites, granulites, amphibolites, schists and quartzite. The age of the volcanic activity has been estimated as Pleistocene to Holocene. Active geothermal surface manifestations are rare in Katwe geothermal prospect. The only surface thermal manifestations in the Greater Katwe geothermal prospect are hot springs located in the Lake Kitagata crater, and warm springs and travertine deposits that have built up tufa in the Lake Katwe crater. The maximum surface temperatures in the hot springs in Lake Kitagata crater is 70°C. Review of the geological setup of the Katwe-Kikorongo area indicates that the geothermal resource at Katwe is small and may not be adequate for power generation (Omenda, Lagat, & Wamalwa, 2015). However, more detailed studies are required to evaluate possible existence of small and discrete geothermal systems along geologic structures.

- **Panyimur Geothermal prospect**

Panyimur geothermal prospect located in northwest Uganda along by NNE-trending and ESE-dipping normal rift faults of the Western Branch of EARS. The lithology consists of Precambrian metamorphics and gneiss which have been faulted with dominant structural trend being NNE striking faults of possible Quaternary age. Hot springs are closely related to the faults and span an area of length 1.25 km. The hot springs are located along relatively small step-overs. The conceptual models proposed for Panyimur include: 1) downflow and upflow in fault/fracture hosted permeability within the damage zone and fault splays directly associated with the lower fault; 2) scenario 1 with 125 °C extending to

shallower depths where geothermometers re-equilibrate in a shallow outflow aquifer, implying a larger volume system; and 3) either scenarios 1 or 2 coupled to up-dip outflow in a sand or gravel formation toward the lake. Resistivity surveys define conductors in the downthrow side of the basin with some indication of control by geothermal systems associated with the fault zones. Reflection seismic across the hot springs at Panyimur and analyses of well logs from a nearby oil exploration well support the possibility of formation-hosted outflows of hot water toward the Lake Albert in a manner consistent with the MT and TEM. The Ministry of Energy and Mineral Development has planned to undertake drilling of thermal gradient holes across the hot springs area to further constrain the anomalies.

Direct use applications

The potential for direct use is difficult to estimate as it depends on the proximity of the heat source to potential end-users. Although not actually a direct use of geothermal heat, salt mining is an industry already utilizing geothermal resources at Katwe and Kibiro from shallow salty thermal aquifers. At Kibiro, hot geothermal brine is concentrated using dry soil by capillary attraction, the impregnated soil is then scooped and dissolved in water, and the separated brine is evaporated to dryness by boiling. At Katwe, the method is different from that one at Kibiro, at this place, the brine is channeled into concentration ponds from which the salt solidifies on the surface by natural evaporation during dry weather. The salt is then scooped, dried, and sold within Uganda, the DRC, as far as Rwanda and Tanzania (Bahati, 2008). Support to this economic activity may be implemented in the form of further academic research, i.e., it has been established that brine evaporation flux could be speeded up, and, that recrystallization could be a viable technique for improving the purity of the produced salt.

Several artisanal wellness spas using geothermal waters are known to exist in Uganda, especially in the western part of the country, i.e., Kitaga, Sempaya, Rwagimba, Amoropii, Buranga, Ihimba, and Kibiro. These hot baths are popular with the local population and water temperatures may reach close to boiling point (100^{o}C). This therefore, suggests that the facilities may attract tourists as well if the facilities are well built. The only known in-house use of geothermal energy is at Kisiizi hospital situated in Rukungiri District, SW-Uganda, where hot water at a temperature of 32^{o}C is tapped from a hot spring and used in hospital for bathing and other domestic uses (Bahati & Natukunda, 2008). It is clear, however, that direct potential applications of geothermal heat in respect of food processing exist across the country. Although without specifying the source of heat, the CTCN study (CTCN, 2020) emphasizes plenty of opportunities for vegetables and grain drying within Kibiro area, tea leaf and fish drying at Buranga and Panyimur areas (Natukunda & Valdimarsson, 2018).

Policy, regulatory and institutional framework for development of geothermal resources

Institutional framework

Uganda's Electricity sub-Sector is run under a liberalized set up following the enactment of the Electricity Act, 1999. The enactment of the Electricity Act, 1999, mandated the unbundling of Uganda Electricity Board (UEB) which was a monopoly managing generation, transmission, distribution, sale, import, and export of Uganda's Electricity. Uganda's Electricity Supply Industry is now regulated under the Electricity Act, 1999, Chapter 145, the Energy Policy, the National Environment Act, Chapter 153, and the Statutory Instruments and Guidelines issued by the Electricity Regulatory Authority (ERA) (Figure 7).

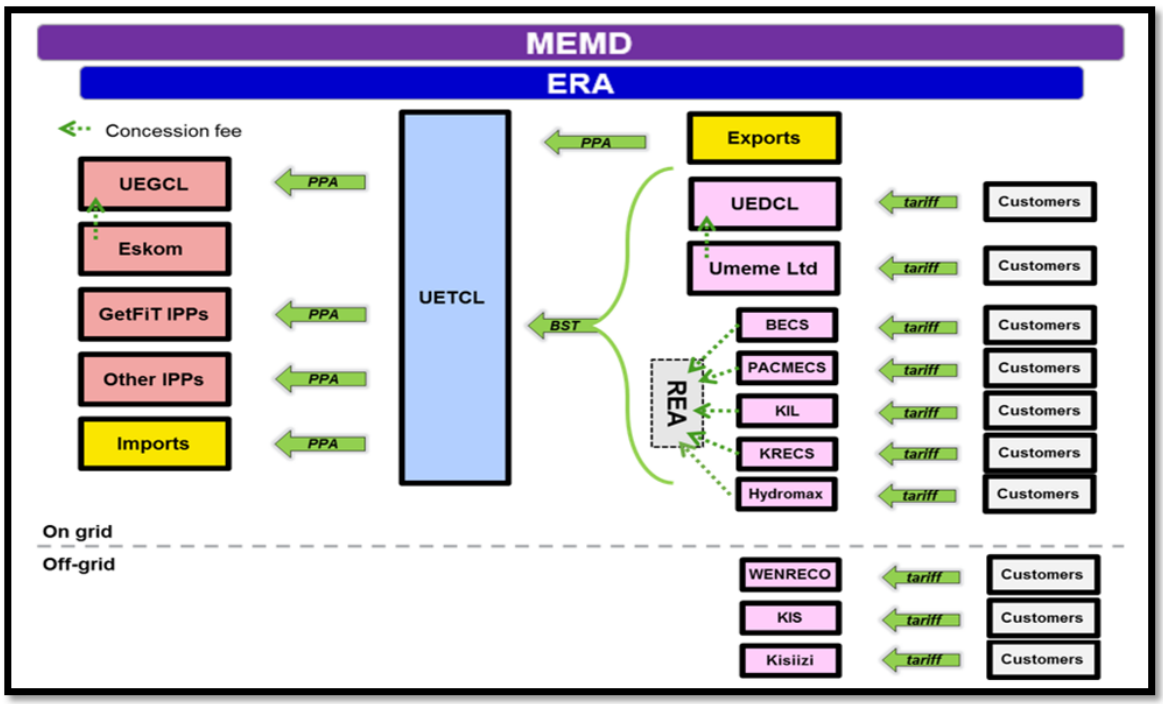

Figure 7: Institutional Framework of electricity sector in Uganda

- **Ministry of Energy and Mineral Development (MEMD)**

The Ministry of Energy and Mineral Development is the Policy head of Uganda's Electricity Supply Industry to whom ERA is directly answerable. The mandate of the MEMD is to establish and promote the development of energy and mineral resources for social and economic development. The Ministry provides policy guidance in the development and exploitation of the energy resources and works with the industry regulator to create an enabling environment in order to attract investment in the development, provision, and utilization of energy resources. Uganda has geothermal directorate in the Ministry of Energy and Mineral Development (MEMD). However, Uganda highly depends on private developers for geothermal exploration in the country.

- **Electricity Regulatory Authority (ERA)**

The Electricity Regulatory Authority is the legal supervisor of Uganda's Electricity Supply Industry. ERA was established in the year 2000 as a body corporate, with the capability to sue or be sued. ERA is mandated by the Electricity Act, 1999, to issue licenses with the attendant license terms and conditions for electricity generation, transmission, distribution, sale, import, and export of electricity. ERA is also mandated to establish a Tariff structure and approve rates of charges, among other functions. ERA is duty-bound to conduct its functions in an open, objective, fair, reasonable, non-discriminatory, transparent manner, and also promote fair competition in the liberalized electricity supply industry. ERA ensures that utilities earn a reasonable rate of return on their investments necessary to provide a quality service at affordable prices to the electricity consumer.

As a way of growing access to clean energy across the country, ERA has licensed several electricity distribution operators across the country to serve the hitherto unserved and predominantly rural community. The number of electricity distribution companies now stands at nine (9). The distribution companies are: Umeme Limited, West Nile Rural Electrification Company (WENRECo), Uganda

Electricity Distribution Company Limited (UEDCL), Bundibugyo Electricity Cooperative Society (BECS), Kyegegwa Rural Energy Co-operative Society (KRECS), Pader-Abim Community Multi-Purpose Electric Co-operative Society (PACMECS), Kilembe Investments Limited (KIL), Hydromax, and Kalangala Infrastructure Services Limited (KIS). These companies are operating in various regions of the country, which has increased access to electricity.

Policy and regulatory framework

- **Renewable Energy Policy 2007**

Based on Uganda government's commitment to the development and use of renewable energy resources, Renewable Energy Policy was adopted. Renewable Energy Policy is a concretization of this commitment, setting out Government's policy vision, goals, principles, and objectives for promoting sustainable utilization of renewable energy in Uganda. It aims to provide a framework to increase in significant proportions the contribution of renewable energy in the energy mix (from 4% in 2007 to 61% by 2017).

In order to achieve the goals, objectives, and targets of the Renewable Energy Policy, five main programs are under implementation. And in the power generation program, geothermal energy is underway of basic studies on identified resources, promotion or tendering of sites to the private sector, and development of projects by the private sector. According to the Renewable Energy Policy, the installed capacity of geothermal plants would have been 25 MW by 2012 and 45 MW by 2017. However, there are no geothermal plants constructed in Uganda yet. However, revised evaluation methods is informed by the new understanding on the geothermal resource types associated with the Western Branch of EARS which suggests possibility for small size ORC based power plants than large size flash plants that had been envisaged earlier.

- **Regulation for Geothermal Power Plant License and Authority - Electricity Act 1999**

Electricity Act 1999 is an Act to provide for the establishment of the Electricity Regulatory Authority, to provide for its functions, powers and administration, to provide for the generation, transmission, distribution, sale and use of electricity; to provide for the licensing and control of activities in the electricity sector; to provide for plant and equipment and for matters relating to safety; to liberalize and introduce competition in the electricity sector; to repeal the Electricity Act; to provide for a successor company to the Uganda Electricity Board and for connected purposes. Developers who intend to establish renewable energy power project under the REFIT are required to fulfill requirements and obligations of the Electricity Act, 1999.

- **Public Private Partnerships Act, 2015**

Public Private Partnerships Act contains provisions on PPP agreements; functions of contracting authorities, accounting officers, project officers, project teams and evaluation committees; role of the private party in a public private partnership; management of public private partnerships; project inception and feasibility studies for PPPs; procurement of PPPs; disqualification of bidders and the evaluation of PPP bids; PPP agreements and the monitoring of the projects; bidding methods; procurement procedures and types of PPP agreements, and other related matters. PPPs are well established in Uganda. While the transmission segment is wholly owned by the Government of Uganda, the distribution segment, just like generation, is liberalized and has private players. The government-owned distribution company is Uganda Electricity Distribution Company Ltd (UEDCL).

- **National Environment Act, 2019**

National Environment Act is an Act to repeal, replace and reform the law relating to environmental management in Uganda; to provide for the management of the environment for sustainable development; to continue the NEMA as a coordinating, monitoring, regulatory and supervisory body for all activities relating to environment; to provide for emerging environmental issues including climate change, the management of hazardous chemicals and biodiversity offsets; to provide for strategic environmental assessment; to address environmental concerns arising out of petroleum activities and midstream operations, to provide for the management of plastics and plastic products; to establish the Environmental Protection Force; to provide for enhanced penalties for offenses under the Act; to provide for procedural and administrative matters; and for related matters. National Environment Act, 2019.

- **Environmental Impact Assessment Regulations, 1998**

The EIA Regulations elaborate in detail on the provisions of the National Environmental Act and present the details of the EIA process and roles of various stakeholders. The Regulations also stipulate it as an offense for any person to commence, proceed, or execute any project without approval from NEMA. The Regulations also advocate for the principle of full disclosure in the conduct of EIAs and make it an offense to make false statements in an EIA.