Geothermal Development in the Democratic Republic of the Congo-a Country Update

Pacifique S. Mukandala¹, Célestin K. Mahinda²
Université Officielle de Ruwenzori
Observatoire Volcanologique de Goma

amipacmknl@gmail.com, mahindageophys@gmail.com

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ABSTRACT

The Democratic Republic of the Congo is an energetically diversified country: biomass, hydropower, solar energy, wind energy, hydrocarbons, biogas and biofuels, geothermal energy, mineral coal, nuclear energy. The country is very interested in hydropower, the small amount of which is consumed locally when the large amount is exported out of the country. Its abundant potential can alleviate the energy needs of much of Africa. Other sources of energy have historical, but recent, applications. So much of the country remains in the dark. Facing various development challenges, the country is increasingly interested in other sources of energy other than hydropower. This is the case with geothermal energy, the potential of which has not yet been assessed. Geothermal occurrences are located in the east of the country in the western branch of the East African Rift. The country thus has an institutional pilot framework in charge of geothermal energy. This framework is located in the province of North Kivu. Geothermal energy is now more and more focused. Several skills are being trained.

With the aim of diversifying and promoting the local industrial production, the country has adopted a policy of development and diversification of its energy resources. A trend is more and more turned towards the valuation of geothermal resources in the eastern part of the country. The geothermal resources are confirmed in this part of the country. The government would therefore like to work with several partners in terms of diversifying its energy consumption. The geothermal sector is a key sector in this objective. The government is therefore prepared to work with all public and private partners in the geothermal sector.

1. Introduction and context

All activity sectors in a country need the energy to function in order to contribute to economic growth and the improvement of the social life of the population (Taty C., and al., 2014). The economic challenge considers energy as a source and consequence of development (Favennec J P, 2009). Energy is an engine for economic development. It is necessary for the creation and maintenance of industries; it facilitates trade and services and simplifies communications and transport systems. Electricity plays a central role in energy
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The Democratic Republic of the Congo is a country located in the heart of the African continent, straddling the equator. The national electrification rate of the Democratic Republic of the Congo (DRC) is currently 9% and only 1% if only rural areas are taken into account (76.8% of the Congolese population). As has often been said, the DRC has immense energy reserves. Indeed, in addition to having a subsoil rich in minerals, this country also has enough energy potential to supply electricity to three-quarters of the African continent (Esseqqat, H., 2011). The energy needs of DR Congo are growing more and more every day.

According to the statistics of the energy 2011 balance, the overall energy supply is evaluated at 24,435 ktep (source SIE / RDC), of which 93.2% of biomass (22,781 ktep), 3.7% of electricity (908 ktep), and 3% of petroleum products (746 ktep). The DRC produces 25,000 barrels of crude oil per day (on average) which exports in total. The net balance of its imports (14 ktep) and exports ((-) 79 ktep) of electricity is estimated at (-) 65 ktep.

It imports electrical energy from neighboring countries (Zambia and Uganda) to supply its isolated border centers, far from existing networks, and for which the implementation of local production infrastructure is expensive. It also exports electric power to Rwanda and Burundi (via the eastern grid), Zimbabwe, and Botswana (via the southern grid). Apart from these interconnection lines, the DRC also supplies some isolated centers in neighboring countries (ANGOLA and the Central African Republic).

The energy consumption of the country is presented in figure 1:

- The energy consumption is presented as follows in DR Congo: Biomass (fuelwood and charcoal): 94.3%
- Petroleum products: 3.3%
- Electricity: 2.4%

The residential sector consumes 96% of the overall consumption of the country against 4% cumulative for the sectors of industry and transport

Figure 1: Energy consumption rate of the country

The geothermal system of the R.D.C. is located in the east of the country. This part of the country is attached to the complex structures of the East African Rift System: it fits within the western branch of the East African Rift. It is also an area of great elevations of the country linked to volcanism (Figure 2).
Geomorphologically, the R.D.C. distinguishes an annular rim (where the plateaus surrounding a central part culminate) and the central basin (a depression in the center of the country). The annular bead also includes the western branch of the East African Rift system (eastern border of the DRC), one of the few regions of the country characterized by mountains and not plateaus.

Geologically, DR Congo includes two major structural groups: The Basement land (Archean shields of an age greater than or equal to 2,500 MA, The belt of the Lower and Middle Precambrian -2,500 to 1,300 MA-, The cover of the Upper Precambrian called the Katanguian) and The Coverage land (A coastal area, between the Atlantic Ocean and the Mayumbe mountains; marine formations of Tertiary and Cretacic age are well developed there; The central basin where deposits of Mesozoic and Cenozoic ages spread; of vast grounds outcrop around the perimeter of the Cuvette; The edge of old land subdivided into six non-connectable regions, and The tectonic ditches of eastern Congo occupied by Cenozoic formations peculiarities and site of recent volcanism).

DR Congo enjoys active volcanological and seismic conditions as is the case throughout the East African Rift. Its active volcanoes are located in the Virunga chain of which Nyiragongo and Nyamulagira are the most active (Figure 3). Several other volcanoes are believed to be dormant, and more are said to be extinct.
The trend from south to north is from tholeiitic and slightly alkaline basalts in South Kivu through more strongly alkaline shoshonites in Virunga, to exceptional kamafugites (potassic nephelinites and melilitites) and carbonatites in the Toro Ankole prospect.

DR Congo has four main seismic zones (Figure 4): a. South Sudan, the Ruwenzori, and the Edouard lake; b. The Virunga, Rutsuru, and Masis; c. The Lake Kivu Basin, Ngweshe, and the Ruzizi plain and d. The rift of the Tanganyika Lake

2. Status of Electricity Production (from all sources of energy)

The DRC is full of proven, abundant, and varied potential and energy resources: biomass, hydraulic power, liquid and gaseous hydrocarbons (including methane gas from Lake Kivu), mineral coal, oil shale, solar and wind potential, tidal power, thermal waters, bioenergy, uranium ore, etc. It should be noted that these resources are not yet fully assessed.
Electricity is one of the major and irreversible factors which condition the economic, social, technological, and cultural development of all nations, all peoples, all communities or any individual taken in isolation (Law No. 14/011 of June 17, 2014, relating to the electricity sector).

Most of the data on electricity production is taken from the national report "Sustainable energy for all by 2030". Other works consulted are those of the government of the Democratic Republic of the Congo.

2.1. Hydraulic energy potential

The technically exploitable hydroelectric potential is estimated at 774,000 GWh per year, and this would correspond to an exploitable power of around 100,000 MW, distributed (however unequally) between 217 sites listed, including that of Inga, which alone represents 44% of the total potential (i.e. around 44,000 MW). Only 2.6% of this potential has been exploited to date, i.e. around 2,566 MW (divided between 62 sites in operation), of which 69% (i.e. 1,775 MW) at the Inga site (351 MW at Inga 1 and 1,424 MW at Inga 2). The hydroelectric potentialities are greater than 100,000 MW, of which more than 98,000 MW already identified as being able to receive hydroelectric installations ranging from pico to large installations, remain untapped to this day, while at the same time, the access rate of the Congolese electricity is 9%, against an African average estimated at 24.6%. This potential is also unequally distributed among the provinces of the country.

The R.D.C. has 66% of the potential of Central Africa, 35% of the overall potential of the African continent, and 8% of the global annual potential (Kasemuana S. M., 2009).

Figure 5: The hydroelectric potential of DR Congo
2.2. The biomass

The biomass is the most important source of renewable energy in the DRC which conceals 145 million hectares of forest cover: the country alone concentrates more than half of the forests of the Congo Basin, or nearly 10% of the tropical forests wetlands. The forests occupy 66.5% of the national territory, including a dense humid forest for more than half of the forest areas. These potentialities are however very unequally distributed across the national territory.

The regions rich in forest resources have a low human population density, while the few forests available in densely populated regions are subject to increased deforestation following intensive removal of wood fuels for energy needs basic (cooking food, heating, etc.). At the national level, the rate of deforestation in net progression was on an annual average of 0.25% between 2005-2010 (that is to say 400,000 ha of average surface devastated annually). The DRC is home to the second-largest tropical forest in the world after the Amazon, with nearly 155.5 million hectares of forests (R. Eba’a Atyi, N. Bayol, 2009).

2.3. Solar and wind energy

The potential for solar and wind energy is far from negligible. The DRC is located on a strip of high sunshine between 3,500 and 6,750 Wh / m² / day, but the installed capacity of the photovoltaic installations inventoried to date across the country is paltry, only in the order of 90 kW. In the DRC, there are only 836 solar installations for a total power of 83,160 Wp distributed in the former provinces (Kasemuana S. M., op cit).

The wind potential is also underexploited. Anemometric studies, carried out in a few centers and towns in the country at 2 meters above the ground, gave a limited wind potential (and more localized in certain areas, mainly coastal) with average wind speeds varying between 2.3 and 6.5 km / h but susceptible of applications for energy purposes (mechanical energy or motive power and electric wind generator).

2.4. Hydrocarbons

For liquid hydrocarbons, the DRC has three sedimentary basins (Coastal Basin, Cuvette Centrale, and Grabens Albertine and Tanganyika). The reserves estimated in the onshore part of the Coastal Basin are in the order of 5.692 billion barrels. In addition, there are significant reserves, not yet quantified, of the Albertine and Tanganyika Grabens. Only the Coastal Basin is exploited to date with however a marginal production of fewer than 25,000 barrels per day, exported in full.

For gaseous hydrocarbons (associated with petroleum and methane), the gas reserves associated with oil in the Coastal Basin are estimated at 10 billion Nm³ at sea and 20 billion Nm³ on land, not counting the potentialities detected in the Central Basin and in the graben but not yet assessed to date. The Kivu Lake (Graben of Tanganyika) abounds, beyond 300 m depth, enormous quantities of methane gas estimated at 278,000 billion Nm³ of which more than 60 billion Nm³ can be exploited and the capacity for regeneration of reserves is 250,000 Nm³ of gas per year. This enormous gas potential has not yet been developed.

2.5. Biogas and biofuels

For Biogas and Biofuels, the country has immense potential (but not quantified) in plant resources for the development of biogas and biofuels in order to reduce dependence on imported hydrocarbons. The DRC brings together favorable conditions for the development
of biofuel sectors: oilseed crops (palm kernels, rapeseed, soybeans, sunflowers, jatropha, etc.); fermentation of crop residues from sugar cane (production of methanol, ethanol); biogas (methane) from the fermentation of residues and various wastes.

2.6. Geothermal energy

It is more localized in the western branch of the East African Rift. Its potential has not yet been assessed and no application has been made to date. The few geothermal sites identified have not yet been thoroughly investigated. Thermal waters can be used, among other things, for the production of electricity. The geothermal energy was first used in Katanga at the Kyabukya geothermal power plant.

2.7. Mineral coal

The mineral coal potential is estimated at 720 million tonnes (Luena and Lukuga in Katanga province). A first start-up has already taken place to supply the GECAMINES boilers, which are currently shut down due to its low calorific value. The exploitation of this resource is not encouraged in the REDD + strategy because of the environmental problems it causes (emission of greenhouse gases into the atmosphere).

2.8. Nuclear energy

The uranium ore reserves at the Shinkolobwe, Kalongwe and Lwambo mines in Katanga province are estimated at 1800 million tonnes, but no mining or conversion is envisaged for energy production. The several other deposits are not yet fully assessed. This is the case, for example, with the carbonatite deposits of Bingo and Lueshe.

The only national use of nuclear energy is at the level of the “Commissariat Général à l'énergie atomique (CGEA)”, which has a multifaceted and varied mission. The activities of the CGEA are currently oriented in the following sectors: research, control, regulation and industry (Kasemuana S. M., op cit).
3. Status of Geothermal Development in the country

3.1. Geothermal potentials and exploitation historic of the R.D.C.

The DRC is one of the first African countries to know Geothermal. The first geothermal installations have been established in the country since 1953 and produce 0.2 MW (figure 6). This was at the KIABUKWA geothermal site with a temperature of 91°C in Katanga (Maheshwar D., 1984). More than 200 hot springs have been mapped in the DRC and only around 30 have been explored. They are located in the eastern part along the Rift.

![Figure 6: Kiabukwa geothermal power plant, 1953](source: Robert 1956 (photography July 1953))

The DR Congo is a country in Central Africa with high geothermal potential. It has several geothermal prospects:

3.2. The geothermal prospects

3.2.1 The Upemba-Moero-Tanganyika geothermal prospect

About a hundred thermal springs are located in Katanga. Several details on these sources are not yet available. The following sources are the most well-known: Kafinga Hot Spring, Tumba Hot Spring, Niamalonga Hot Spring, Rutuku Hot Spring, Nganza Hot Spring, Mulala Hot Spring, Konkula Hot Spring, Kipia-Lubumbumu Hot Spring, Kafumwe Hot Spring, Kavunwe Hot Spring, Kania Hot Spring, Kianzamba Hot Spring, May Hot Spring, Kansongo Hot Spring, Kaswela Hot Spring, Kayumba Hot Spring, Kisabi Hot Spring, Pundu Hot Spring, Kibimbi Hot Spring, Kafungwe Hot Spring, Kaku Hot Spring, Lofoi Hot Spring, Kabila Hot Spring, Kiabukwa Hot Spring, the thermal spring of Tanganyika (40-50 °C), the thermal spring of Upemba (70-100 °C).

3.2.2 The Kivu-Edouard geothermal prospect

The surface temperature of these sources varies from 20 °C to 100 °C. The following sources are the most well-known: Mayi ya Moto Hot Spring, Walikale Hot Spring, Mutsora Hot Spring, Kambo Hot Spring, Bakoma Hot Spring, Kalumia Hot Spring, Kalumia Hot Spring Luama, Nyawatu Hot Spring, Ruzizi Hot Spring, Mabitabo Hot Spring, Namoya Hot Spring, Kikura Hot Spring, Kyavitumbi Hot Spring, Uvira Hot Spring (44 °C), Nyangezi thermal spring (40 °), Kasongo thermal spring.

3.2.3 The Albertine geothermal prospect
About sixty thermal springs are located in the great Province Orientale. In general, the data are not yet available except for the sole source of Lilida (40 °C).

3.3. History and mapping of geothermal exploration

In some North Kivu sites, the three underground temperatures TNaK1, TNaK2, and TNaK3 are Mayi ya Moto (163-177 ºC), Tingi Sake (255-290ºC). In South Kivu sites all three TNaK1, TNaK2 and TNaK3 give reasonably consistent data. The suggested underground temperatures are therefore as follows: Muganzo (339-364ºC), Kankule (337-369ºC), Mahyuza (345-374ºC), and Maziba (275-294 º C). (1Giggenbach, 1988; 2Fournier, 1979; 3Truesdell, 1975 cited by Mambo and al.). Further geothermal tests are being prepared on the geothermal prospects in the Ruwenzori sector.

More than 200 Hot Springs are found out in the eastern part of DRC (Figure 7) and are mainly associated with rift activities. The geothermal resources are also enormous in its Eastern part, notably in the following major's provinces: Katanga, Kivu, and Oriental Province as can be seen in the following figure:

It should be remembered that the geothermal energy of the R.D.C. is closely linked to geology: Volcanism, seismic, rifting.

3.4. Current activities

DR Congo wants to develop its geothermal resources. As such, Provincial Decree n° 298 / CAB / GP-NK / 2015 of October 30, 2015, establishing in North Kivu Province of a Comité de Pilotage pour le Développement des Ressources Géothermiques du Nord-Kivu (Steering
Committee for the Development of Geothermal Resources, CPDRG) is intended to revive of this sector. This public structure works in collaboration with private and public partners in the North Kivu Province. Through this experience in the Province of North Kivu, an extension is planned within all of Kivu, greater Katanga, and the Province Orientale.

The researchers from the Université Officielle de Ruwenzori (Ruwenzori State University) have come up with a scientific demonstration recently. They broadened their knowledge of geothermal energy in the Ruwenzori sector by discovering three new geothermal prospects: Kikura, Kyavitumbi, and Kikingi. Their research will thus change the national geothermal mapping. It should be noted that geothermal energy is still used largely for traditional curative reasons.

DR Congo would also like to maintain partnerships within the framework of the training of increasingly competent personnel. These courses can be professional internships, masters and even Ph.D. courses in order to mobilize young people who are increasingly motivated to develop the geothermal sector.

4. Investment

The D.R.Congo is open to all private or public investors need to build their own power plant and need to produce the electricity in order to commercialize in the country wide.

The law No. 14/011 of June 17, 2014 relating to the electricity sector talks about this tendency and invites all the investors to participate to the development of this sector.

5. Outlook and conclusion

The DR Congo enjoys a strategic geographical position in the heart of Africa. It shares its land borders with 9 neighboring countries.

The energy potential of DR Congo is so varied: hydroelectricity, biomass, solar energy, wind energy, hydrocarbons, biogas and biofuels, geothermal energy, mineral coal, nuclear energy. DR Congo has long focused on hydropower. It consumes part of its energy and exports another beyond its national borders. The other energy sectors were not left behind and were interested in low investment.

The current policy of the country tends to extend towards the diversification of its energy resources. Thus, some efforts are focused on the geothermal sector which is still almost in the phase of mobilizing increasingly competent executives. This energy diversification will relieve the country and the sub-region. It can be beneficial even beyond continental borders.

The government of the Republic remains open to all private and public partners in the production and consumption of its energy for the well-being of humanity.

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