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Overview of the Electricity Sector and Impact of the Electricity Regulatory Authority (ARE) in the Democratic Republic of the Congo from 2020 to 2022

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Abstract— **Historically, the national electric utility company (SNEL) had a monopoly in the electricity sector which prevented private companies from participating in the sector in the Democratic Republic of the Congo (DRC). Since 2014, the country applied reforms that allowed penetration of private companies. For effective liberalization, the Congolese government created the Electricity Regulatory Authority (ARE). This paper is a study based on the ARE's 2022 annual report, and best international practices adopted by the ARE. It presents general statistics of the DRC's electricity sector from 2020-2022. Data analysis has shown that the annual electricity production increased from 10 TWh in 2020 to 16 TWh in 2022, a 22.6% growth mostly supplied by renewable energy at 97.46%. Furthermore, 91% of the 3282 MW projected capacity will come from hydroelectricity and solar photovoltaic energy. In 2022 alone, thanks to renewable energy, DRC avoided the emission of more than 10 Mt of CO2.**

Keywords— Africa, Electricity Access, Electricity Regulation, Democratic Republic of the Congo, Renewable Energy,

I. INTRODUCTION

To ensure access to electricity to its population, the Democratic Republic of the Congo (DRC) has liberalized the electricity sector by promulgating law No. 14/011 on the electricity sector since June 17th, 2014 [1][2]. This law aims to make the electricity sector an engine of economic growth, and to increase access to electricity by involving private investors, notably through Public-Private Partnership (PPP). In addition, this law has put in place a new institutional framework comprising the central government, the provinces, the National Agency for Electrification and Energy Services in Rural and Peri-urban Areas (ANSER), and the Electricity Regulatory Authority (ARE) as an independent regulator. This reform in the DRC's electricity sector is very similar to that of other developing countries.

The law No.14/011 established the Electricity Regulatory Authority (ARE) as an autonomous public establishment with a mandate to regulate and monitor electricity sector activities, to ensure transparency, enable free competition and investment, promote financial viability within the sector, to set and enforce standards and norms. ARE is also responsible for protecting the rights of end-users and operators. The success of the sectoral policy depends, among other things, on the mitigation of risks related to the legal and regulatory framework, the protection of consumers, and technical risks that operators face while supplying electricity services. In the exercise of its missions, ARE plays a fundamental role in managing the risks. As a regulator, ARE ensures good governance of the electricity sector in the DRC.

This paper is based on a study of the 2022 Annual Report of ARE [1] and presents various electricity performance metrics of the DRC's electricity sector from 2020 to 2022. The methodology consisted of collecting data from several operators in different provinces to assess the impact of ARE on the Congolese electricity sector. Since the existence of ARE, annual electrical energy production in the DRC has increased from 12,460,200,997 kilowatts-hours (kWh) in 2020 to 15,287,152,522 kWh in 2022, this is a 22.6% growth. In 2022, the DRC electricity installed capacity reached a total of 2980.721 Megawatts (MW) of which 2901.6 MW (97.54%) come from hydroelectricity, 75.6 MW (2.35%) from diesel generators and 3.5MW (0.11%) from solar power. These indicators show a strong preponderance for renewable energy and growth in the Congolese electricity sector. However, there is a significant gap between population growth and energy needs. The portfolio of projects approved by the ARE aims to reduce this gap by adding 3,282.22MW of installed capacity provided all projects are implemented.

ARE also ensures that norms and standards are respected in the country. In 2022, ARE has certified the 14.6MW IVUNGU Hydroelectric Power Plant for the Virunga Energies company in North Kivu and its associated 33kV Medium Voltage (MV) transmission lines. The hydroelectric power plant of BUSANGA in Lualaba is underway and will soon be finalized. Regarding tariff proposals, as the technical entity in charge of receiving, analyzing, and auditing electricity tariffs,

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ARE has examined four tariff proposals relating to projects with a total capacity of 1265 MW.

Based on its mission to resolve conflicts between operators and consumers, ARE has set up a consumer unit that handles complaints filed by consumers against their electricity suppliers. Furthermore, ARE has presented and won the candidacy of the DRC as the country to host the headquarters of the Central African Regional Regulators Commission (CORREAC) an institution of the Economic Community of Central African States.

II. PRESENTATION OF ARE

This section briefly presents the Electricity Regulatory Authority of the Democratic Republic of the Congo.

A. Organigram of ARE

The Electricity Regulatory Authority is composed of three entities: the board, the general directorate, and the college of statutory auditors as shown on the organigram in Fig.1.

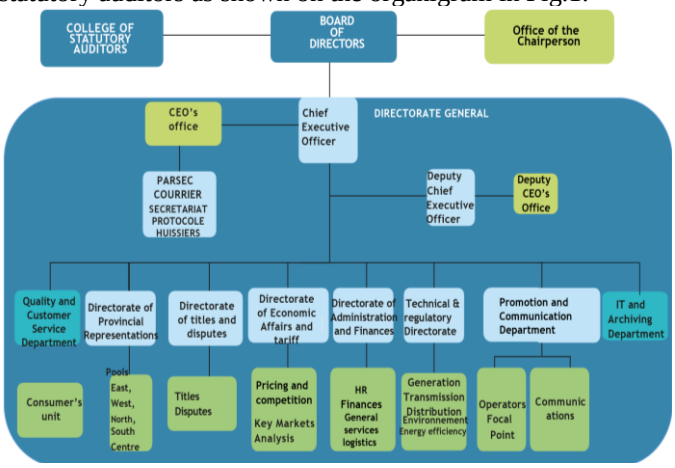

Fig. 1. Organigram of the DRC's Electricity Regulatory Authority [1].

The general directorate is the executive entity responsible for the day-to-day operations. In 2022, ARE counted 33 employees with 41.7% of women and 58.3% men. More information can be found at [3].

B. Missions of ARE

Decree No. 16/013 of April 26th, 2016 created ARE [4]. ARE's missions are summarized in article 3 as follow:

- To ensure the regulation of the activities of the electricity sector in DRC by the control of the norms and standards applicable in the electricity sector.
- To guarantee and monitor the application of the principles and rules of transparency and free competition in the electricity market.
- To contribute to the creation of a business climate that favors investment and proper implementation of activities in the electricity sector.
- To receive, analyze, and audit electricity sector tariffs.
- To resolve conflicts between end-users and/or between electricity suppliers in the electricity sector.

C. ARE's roadmap for 2022-2024

The objectives can be broken into seven points which are in line with the following seven strategic axes:

- Competitiveness and participation of the private sector for access to electricity under the best price conditions.
- Consumer protection and development of a non-discriminatory market.
- Favorable conditions for security of electricity supply.
- Regulated prices for activities in the energy sector that reflect actual costs, reflect transparent costs, translate signals and incentives based on applicable tariff methods.
- The unbundling of vertically integrated electricity suppliers into a competitive market.
- Workforce development and capacity building of ARE staff through training to develop expertise.
- The integration of the ARE into the international network of regulatory bodies, allowing it to participate actively in regional and international initiatives.

III. THE ELECTRICITY SECTOR IN THE DRC

The DRC's electricity sector faces major challenges, including low generation capacity, inefficient infrastructures, and low access to electricity. The country's hydroelectric potential estimated at over 100 gigawatts (GW) [6] could make a transformative contribution to the country's economic development.

This section presents an overview of the DRC's electricity sector and various performance metrics from 2020 to 2022. In terms of methodology, the data in this publication were calculated by the Electric Regulatory Authority based on data collected from the following operators: Congolese national electric utility company (SNEL SA), Virunga Energies SAU, NURU SASU, Bboxx, Altech, ENERKA, Sicohydro, SOCODEE SA, and SACIM.

A. Annual Electricity Production in the DRC

First, the annual production of electrical energy in the DRC will be presented. Table I shows the annual production of electrical energy in the DRC since the implementation of ARE. In 2022, the DRC produced 15,287 GWh of electrical energy compared to 12,460 GWh in 2020, i.e. a growth of 22.6%. This growth in annual electricity production is encouraging and must increase further to fill the gap with energy demand linked to population growth.

TABLE I. DRC ANNUAL ELECTRICAL ENERGY PRODUCTION, 2020 - 2022.

Description	Year 2020	Year 2021	Year 2022
Total annual production (kWh)	***12,460,200,997***	***14,168,208,360***	***15,287,152,522***
Genset (kWh)	7,006,730	2,692,170	5,551,870
Solar PV (kWh)	253,462	1,034,471,554	2,089,689,207
Hyrdopower (kWh)	12,452,940,805	13,131,044,636	13,191,911,445

Indeed, these values of the national annual production remain far below the energy demand forecasts over this period evaluated at (81 TWh) by the Ministry of Energy in 2020 according to the demand analysis model. It is important to note that, in 2022, 99% (15,181GWh) of the electrical energy produced in DRC came from renewable sources.

B. Installed Capacity by Province and by Source

This compilation was made on the entire electricity supply chain, from generation, transmission, distribution to commercialization. The DRC installed capacity reached 2980,7MW in 2022. Table II shows the breakdown of installed capacity with power plants listed by province and by energy source.

TABLE II. INSTALLED CAPACITY BY PROVINCE AND BY SOURCE IN DRC IN 2022

Province	Hydro	Genset	Solar PV	Total (MW)
Bas-Uele	0.44	2.134	0	2.574
Equateur	0	4.41	0	4.41
Haut-Katanga	119.22	0.3	0	119.52
Haut-Lomami	9	1.244	0	10.244
Haut-Uele	96.65	3.78	0.345	100.775
Ituri	12.5	0	0	12.5
Kasai	1.5	2.904	0.1	4.504
Kasai Central	3	5.656	1.2	9.856
Kasai Oriental	34.73	6.8	0	41.53
Kinshasa	0.15	0	0	0.15
Kongo Central	2014.6	17.492	0	2032.092
Kwango	0.22	0.5	0	0.72
Kwilu	10.73	1.98	0	12.71
Lomami	0	1.364	0	1.364
Lualaba	374.54	0.1	0	374.64
Mai-Ndombe	0	0.176	0	0.176
Maniema	17.05	1.652	0	18.702
Mongala	0	2.996	0	2.996
Nord-Kivu	34.96	4.4	1.85	41.21
Nord-Ubangi	11.74	0	0	11.74
Sankuru	0	0.352	0	0.352
Sud-Kivu	94.672	0	0	94.672
Sud-Ubangi	0	1.886	0	1.866
Tanganyika	46.3	1.988	0	48.288
Tshopo	19.65	13.04	0	32.69
Tshuapa	0	0.42	0	0.42
Total	***2901.652***	***75.574***	***3.495***	***2980.721***

With 2901.65MW produced from hydroelectric power plants and 3.495MW produced from solar photovoltaic plants, renewable energy accounts for a total of 2905.147W or 97.46% of installed capacity in the DRC.

C. Evolution of Installed Capacity vs Available Capacity

This section describes the evolution of the installed capacity versus the available capacity in DRC from 2020 to 2022 as shown in Fig. 2. The situation in the DRC is that several plants have either been shut down or abandoned for several years and some are not operating at full capacity. As a result, the actual power available does not usually correspond to the theoretical installed power, this is clearly seen in Fig. 2.

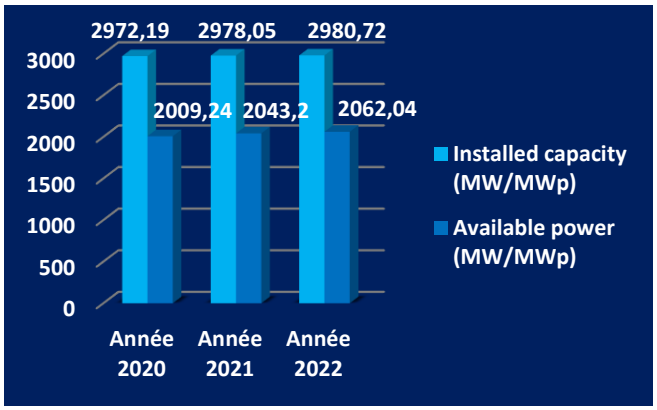

Fig. 2. Evolution of the global installed and available capacity in DRC from 2020 to 2022.

Over the past three years, installed capacity in the DRC has remained almost static with a growth rate of less than 1%. From 2972.19 MW in 2020, the increase was only 5.86 MW in 2021 compared to only 2.67 MW in 2022.

In addition, the contribution of operators of solar photovoltaic home systems in the electrical energy supply chain has been estimated at 2 MW in 2022.

D. Portfolio of New Projects Approved by ARE

With regard to the applications already approved by the ARE, there is a clear interest in solar photovoltaic , which represents more than 80% of the power to be installed by new investors. The results for new projects are therefore listed in Table III.

From the analysis of table III, taking into consideration the expansion of 3282.22 MW from new projects already approved by ARE the total installed capacity of the country is projected to increase from 2980 MW to more than 6200 MW.

TABLE III. INSTALLED CAPACITY OF NEW PROJECTS APPROVED BY ARE FROM 2020 TO 2022

Item	Source	Installed Capacity (MW)	Percentage (%)
1	Hydroelectricity	374.7	11%
2	Solar Photovoltaic	2625.145	80%
3	Genset	181	6%
4	Importation	101.5	3%
	Total	***3282.22***	***100%***

E. National Customer Base

In 2022, the total number of Low Voltage (LV) customers serviced reached 1,181,930 compared to 1,075,107 customers in 2020, a growth of 9.9%.

The number of medium voltage (MV) customers reached 2,553 in 2022, up 9.4% compared to 2020.
Finally, in High Voltage (HV), we counted 70 customers in 2022, an increase of 14% compared to 2020.
The number of customers billed is within a few units to the number of customers served. This is mainly due to the introduction of an electronic payment system for electricity bills which leverages information and communication technologies (ICT) and digitalization such as prepaid electric meters and mobile money which allow customers to pay their utility bills from their cellphones. Table IV summarizes the national clientele in DRC from 2020 to 2022.

TABLE IV. THE DRC'S DOMESTIC CUSTOMER BASE FROM 2020 TO 2022

Description	Year 2020	Year 2021	Year 2022
Customer Served			
No. of HV Customers	61	65	70
No. of MV Customers	2,333	2,529	2,553
No. of LV Customers	1,075,107	1,121,144	1,181,930
Total Clients served	***1,077,501***	***1,123,738***	***1,184,553***
Customer Billed			
No. of HV customers billed	53	58	63
No. of MV customers billed	1,709	1,735	1,808
No. of LV customers billed	797,459	799,914	843,093
Total invoiced customers	***799,221***	***801,707***	***844,964***
Households Served and Billed			
No. of households served	987,786	1,031,171	1,087,897
Numbers of households billed	744,096	746,574	786,519

F. Electricity Coverage, Service Rate, and Access

According to the United Nations PREP, 2007, the rates are defined as follows.

1) Geographical coverage rate (GCR)

It is the ratio between the population living in electrified localities (Pe) to the total population of the area. Assume that P is the population of DRC, thus considering the number of households served in Table IV with an average of 6 inhabitants per household, the GCR was calculated based on Equation 1, and the results were shown in Fig. 3 for the year 2020, 2021 and 2022.

$$GCR=Pe/P \quad (1)$$

2) Service rate (SR)

This is the ratio of the population with effective access to the service(Pa)to the population of the electrified localities (Pe). The SR was calculated based on Equation 2.

$$SR=Pa/Pe \quad (2)$$

3) Electrification rate (ER)

This is the ratio of the population served to the total population of the area. The ER was calculated based on Equation 3.

$$ER= Pa/P =SR*GCR \quad (3)$$

4) Access rate (AR)

With respect to electricity, it is those who have access to electricity compared to the total population. The access rate is therefore identical to the electrification rate.

In 2022, the geographic coverage rate reached 35.94%, while the service rate reached 18.56%, and access to electricity was around 6.67% in the DRC. The small growth in AR is because the demographic growth is much higher than the growth of the electricity sector. To bridge the gap, large investments in electrical infrastructures projects are needed. The results are summarized in Fig. 3.

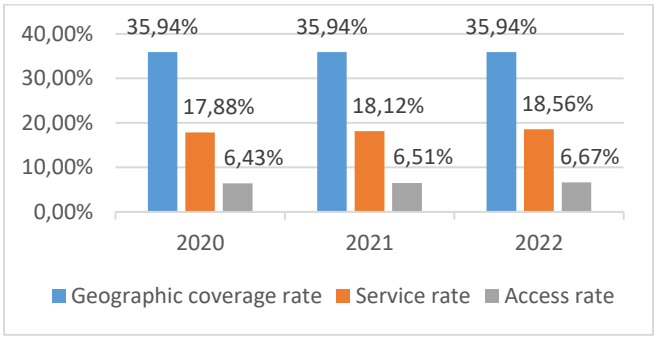

Fig. 3. Summary of electricity coverage, service and access rates in the DRC from 2020 to 2022.

The service rate would certainly be higher than 18.56% if we had been able to obtain data from all the operators. It is also worth mentioning the difficulty of accessing the most up-to-date data on the population of the various cities and towns. According to the World Bank's country profile for the Democratic Republic of the Congo, the population of the DRC was estimated at 92,234,000 in 2020, 95,000,000 in 2021, and 97,800,000 in 2022.
The DRC has 37 operators in the electricity sector, a big improvement. Fig.4 shows a distribution of operators in DRC by segment. This information was compiled by ARE based on data from ARE, the Ministry of Water Resources and Electricity, the Federation of Enterprises in DRC (FEC).

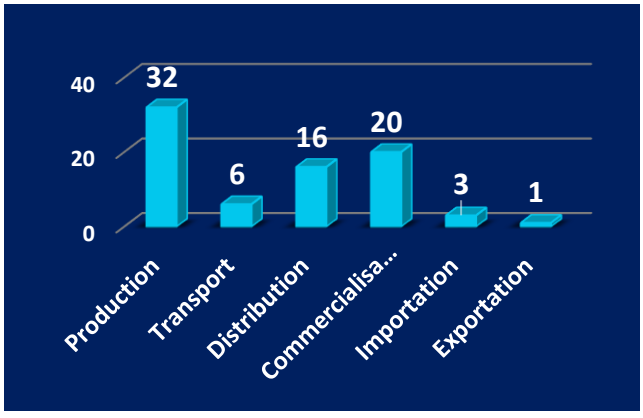

Fig. 4. Distribution of operators by activity in the electricity sector.

IV. CO_2 AVOIDED DUE TO CLEAN ENERGIES IN DRC

The DRC is a strong ally in the fight against climate change for two main reasons. First, with the Congo River alone, the DRC has water resources that represent 10% of the world's water reserves. In addition, the DRC has the second largest forest in the world covering approximately 152 million hectares which absorbs carbon dioxide (CO2). The electricity produced from renewable energies (hydroelectricity, solar, etc.) considerably reduces the use of charcoal and mitigates the deforestation of the Congolese massif. Secondly, the DRC contains 60% of the world's cobalt reserve, as well as other minerals such as gold, copper, lithium, diamond, manganese which are necessary for the fabrication of solar panels, wind turbines, batteries, electronic parts etc. Our minerals allow the manufacture of the technologies for the energy transition and for industry 4.0.

According to the Intergovernmental Panel on Climate Change (IPCC), climate change can lead to significant damage such as floods, droughts, storms, destabilization of the forest ecosystems, decline in agricultural production, etc. However, the most abundant greenhouse gas (two thirds) is carbon dioxide (CO_2), largely produced by the combustion of fossil fuels and mainly responsible for climate change [5]. Considering the electrical energy mix giving rise to the annual production in DRC (Hydroelectricity + Photovoltaic + Thermal) listed in table V, assuming that the direct emission of CO_2 of genset, hydroelectric power plants and solar photovoltaic systems are respectively 700, 20 and 45 gCO_2 eq/kWh [7][8], we have used Equation 4 to calculate the equivalent amount of CO_2 avoided thanks to the use of renewable energies instead of fossil fuel:

$$tCO2=ERE*(T-Re) \quad (4)$$

Where:

- tCO2 is the equivalent amount of CO2 avoided with the use of renewable energy.
- ERE is the kWh of Renewable Energy.
- T is the gCO2/kWh Thermal
- Re is the gCO2/ kWh Renewable Energy.

Fig. 5 shows the equivalent million tons (Mt) of CO_2 avoided in the DRC from 2020 to 2022 totaling 28.41 Mt. The DRC avoided 10.34 Mt of CO_2 in 2022 and 8.46 Mt of CO_2 in 2020, an increase of 22%.

In 2022, by comparison, these equivalent mega tons or million tons of CO_2 avoided in the DRC in 2022 is equivalent to removing approximately 252,916 fossil fuel vehicles from road. The assumption is that the car is running on diesel with a consumption of 16 l/100 km and an average of 150 km driven in one day [9].

TABLE V. ENERGY ANNUAL PRODUCTION FROM 2020 TO 2022

Description	Year 2020	Year 2021	Year 2022
Total annual production (kWh)	***12,460,200, 997***	***14,168,208, 360***	***15,287,152, 522***
Thermal production (kWh)	7,006,730	2,692,170	5,551,870
Photovoltaic prouction(kWh)	253,462	1,034,471,554	2,089,689,207
Hyrdoelectric production (kWh)	12,452,940, 805	13,131,044, 636	13,191,911, 445

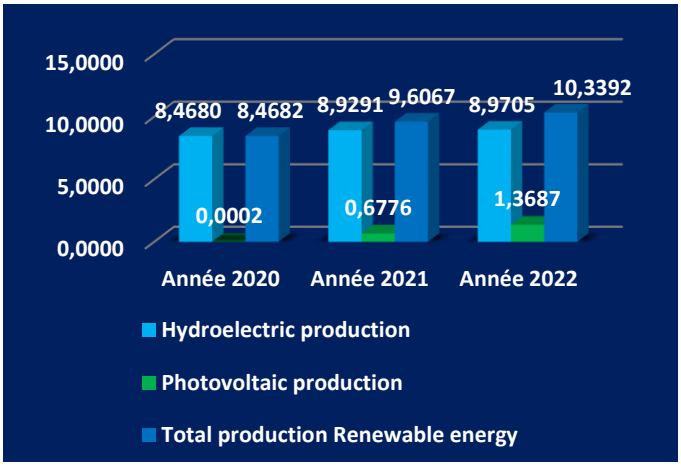

Fig. 5. Equivalent million tons of CO2 avoided in DRC 2020- 22.

Similarly, this amount of CO_2 avoided by using renewable energies in 2022 corresponds to planting approximately 413,568,000 trees in the scenario where a newly planted tree absorbs at least 25 kg of CO_2 [10].

V. CONCLUSION

This paper presented a statistical report on the electricity sector based on data collected by the electricity regulatory authority (ARE) in the Democratic Republic of the Congo. The data show that, since ARE was created, the annual electrical energy production has increased by 22.6% and the business climate has improved in the electricity sector from 2020 to 2022. In addition, renewable energies represent 99% of the energy produced in DRC. Moreover, the quantity of CO2 to be emitted into the environment decreased by 10.34 million tons in 2022, 9.61 million tons in 2021, and 8.46 million tons in 2020.

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