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Evaluation of economic consequences of electricity transmission and distribution losses in Nigeria

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Abstract
The aimed of the study is to identify the causes, estimate economic consequences and recommend solutions to the electricity transmission and distribution losses emanating from Electricity Distribution Companies (DisCos) in Nigeria. Secondary data from Nigerian Electricity Regulatory Commission (NERC) and database of International Centre for Investigative Reporting (ICIR) were analyzed using simple percentages based on the cumulative average transmission and distribution losses of the eleven DisCos in Nigeria. In addition, survey of related peer reviewed empirical works served as supplementary data sources after deployment of all the needed energy conversions for conformity with various energy data units available. The study found the rate of electricity transmission and distribution losses to be 53.83%, or about 1,973.318MWelectricity in Nigeria. About 3665.83 Mega Watt (MW) was the estimated generated energy that is sent out to National grid by the generating companies (GenCos) in Nigeria for the DisCos to distribute to all the tariff classes of consumers (Residential, Commercial, Industrial, Special and Street Light) relative to band hours. The results translate economic loss in billions of naira from the existing DisCos, with YolaDisCo having the highest industrial monetary transmission and distribution losses amounting to Fifty billion, forty-two million, eighty-three thousand, six hundred and seventy (N50, 042,083,670) Naira based on maximum of 16 hours electricity supply at N66.04 for the year 2020.Identified causes of the electricity losses were overloading on transformers, vandalization of transmission equipment, poor maintenance regime which is recommended to be reversed to give positive; economic, health, and social benefits.

Keywords: DisCos, Distribution losses, Economic growth, Electricity Transmission, GenCos.

1. Introduction

Access to sufficient, stable and sustainable energy is pre-requisite for meaningful growth and development of a country. Availability of electricity is the most powerful catalyst for economic, industrial and social developments of any state, and for electric power to get to the final consumers in proper form and quality, transmission and distribution losses had to be reduced to the minimum (Bhatti, et al.,2015). Electricity transmission and distribution losses is a global issue, this is because verifiable data from world development indicators shows all countries are having different magnitudes of the electricity losses. As of march, 2022 data points from world development indicators which stops at 2014 shows the global average electricity transmission and distribution losses is 8.25%, for Sub-Saharan Africa is 11.74 but Nigeria has worrisome rates of 16.11% which is above both world and African average (World Bank, 2022). Among the tasks of this study is going to be identification of the causes of

such electricity losses in Nigeria and the associated economic consequences. Insufficient electric power supply has impacts and cost ramifications that can lead to absence of great strides in human development, better the economy and sustainable development (Ugwoke, et al., 2020).

Electricity losses in Nigeria seems to be behind series of glaring losses ranging from economic losses (fall in revenue from the energy sales, industries collapses, loss of gainful employment), social losses (unemployment related increase in social vices like kidnapping, robbery, theft, etc) health (increase in death rates due absence/shortages in power supply to power medical gadgets, damage to medicines that need refrigerators, light and power outages during surgery, etc.) and even political loses were politicians lose potential vote because of failure to fulfilled electricity campaign promises among others.

Thus, in an effort to provide sufficient electricity for better economic progress, Nigerian government gave room for the existence of many electricity generating companies (GenCos) and distribution companies (DisCos). These companies in process of providing their services faced numerous challenges that hinder efficient electricity supply; one of these challenges they have to tackle is electricity transmission and distribution losses.

Exploring and unveiling the huge electricity losses requires the assessment of the activities of electricity Generating Companies (GenCos) to know the quantities of electricity generated and for Distributing Companies (DisCos) to know the quantities reaching the end users in Nigeria. This will help in pin-pointing where the sources of the inefficiencies or losses are and the monetary values lost, for easy tackling, as there are several GenCos and DisCos that are respectively generating and distributing electric energy in Nigeria.

1.1 Active GenCos in Nigeria and Energy Sent Out to Grid, In 2020

There were about twenty-seven (27) electricity generating stations retrieved from Nigerian Electricity Regulatory Commission's database as of 14th April, 2022. Table1 below is presenting GenCos performance based on the arrangement of the Electricity Generating Companies (GenCos) in Nigeria, from Delta (1), Egbin(2), Kainji(3), Jebba(4),Afam IV (5), Odukpani(6), Okpai(7), Geregu NIPP(8), Olorunsogo(9), Omotosho NIPP(10), Omotosho (11), Ihovbo NIPP(12), Ibom power(13), Rivers IPP(14), Gbarain(15), Omoku(16), Paras energy(17), Afam IV-V(18), Olorunsogo NIPP(19), Trans Amadi(20), ASCO(21), AES(22), Alaoji NIPP(23), Sapele(24), Sapele NIPP(25), Shiroro(26) and Azura Edo (27), the sent out to grids by GenCo's are presented below

Table 1: Average Daily Energy (MWh) sent out by Nigerian GenCos stations in 2020

S/NO	GENCOS	ENERGY SENT OUT	S/NO	GENCOS	ENERGY SENT OUT
1	Delta	7.32	15	Gbarain	0.44
2	Egbin	12.07	16	Omoku	1.8
3	Kainji	7.84	17	Paras energy	1.38
4	Jebba	7.15	18	Afam IV-V	1.16
5	Afam IV	5.82	19	Olorunsogo NIPP	0.64
6	Odukpani	6.57	20	Trans Amadi	1.21
7	Okpai	4.34	21	ASCO	0
8	Geregu NIPP	2.16	22	AES	0
9	Olorunsogo	3.02	23	Alaoji NIPP	1.62
10	Omotosho NIPP	0.64	24	Sapele	0.68
11	Omotosho	2.81	25	Sapele NIPP	0.79
12	Ihovbo NIPP	0.65	26	Shiroro	6.57
13	Ibom power	0.95	27	Azura Edo	8.03
14	Rivers IPP	2.32	TOTAL		87.98

Source: Author's extraction from NERC using values as of April, 2022

The generated electricity energy are in thousand units, the total of 87.98 generated energy is 87,980 megawatt hours (MWh), which is 3665.83 Mega Watt (MW) (87,980 divided by 24) as the estimated generated energy. The generated energy is sent out to National grid by the generating companies (GenCos) for onward distribution by DisCos to various categories of consumers to be charged in Naira per Kilowatt hour (N/KWh). The fig 1 below is for the energy sent national grid for transmission and distribution per GenCos stations in Nigeria based on the values from table1.

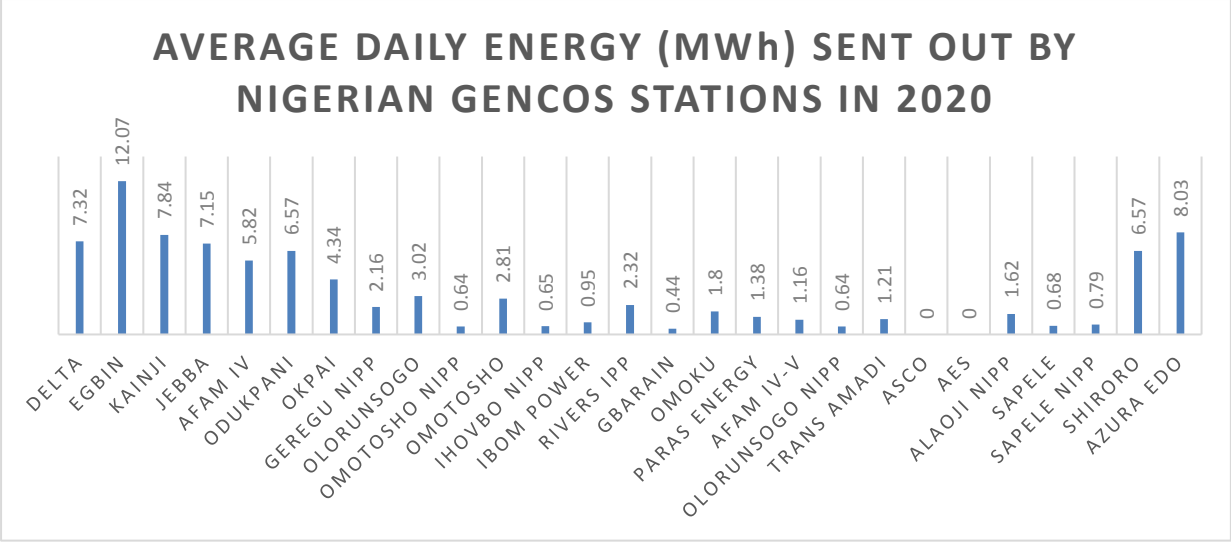

Fig 1: Average daily energy (Mwh) sent out by stations in 2020
Source: Nigerian Electricity Regulatory Commission, NERC, (2022a)

As seen from both fig1 and table1, the total electricity generated is 3665.83 Mega Watt (MW). However, not all the generated energy reaches the end users, this is due to existence of transmission and distribution losses which to some extend are attributed to inefficiencies or transmission and distribution losses in Nigeria. The issues now are, what are the total electricity transmission and distribution losses in Nigeria? What are the causes of these

losses? What is the monetary value of the electricity losses? These questions will be address by the end of this research.

The study first starts by accessing the level of electricity losses. This study captured the year 2020 with available electricity Aggregate Transmission Commercial and Consumer losses (ATC&C) from Nigerian Electricity Regulatory Commission (NERC). Based on losses from the existing eleven (11) electricity Distribution Companies (DisCos) in Nigeria, this is to supplement the world development indicators data which only provides data up to 2014. Losses from transmission were observed to be small as seen in figure2 below.

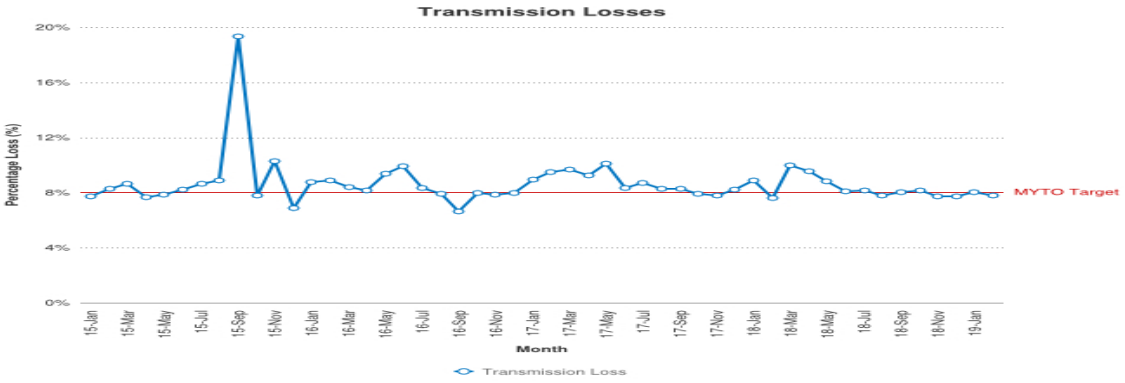

Fig 2: Trend of Electricity Transmission Losses in Nigeria from 2015 To 2019. Source: NERC, (2022)

There is small rate of losses from transmission as captured in figure 1, the highest hovers 18% to 19% in 2015 while from the most recent data available (see fig2), the losses is 8% which is within the global average of single digit.

Electricity is important input for production, as such; its losses are source of concern. In Nigeria, poor electricity supply is one of the biggest challenges to economic development. It results in closure of industries in Nigeria. Constant power outages have a major connection with the trends of big companies closing or relocating from Nigeria (Akuru & Okoro, 2014). It was also stated that "Getting access to electricity ranks as one of the major constraints for the private sector according to the 2020 Doing Business Report" (The World Bank, 2020).

There exists empirical evidence also supporting the need for adequate electricity access for economic prosperity of which one way to do that is via reduction in electricity transmission and distribution losses. This could be achieved by unveiling and addressing the inefficiency in electricity transmission and distribution. Show-casing the need for more electricity access, Adamu and Mohammed (2022), points that "countries with high access to electricity were seen to be better in terms of economic prosperity than those with low access to electricity", as supported by data from World Bank development indicators in their work as presented in table 2.

Table 2: Countries levels of Access to Electricity and Economic Growth measured by GDP per capita (constant 2015 US$)

Country	Indicators	2000	2010	2018	2019
U.S.A	Electricity Access(%)	100	100	100	100
	GDP per capita (constant 2015 US$)	48,689.0	52,759.9	59,821.6	60,836.8
CHINA	Electricity Access(%)	96.9	99.7	100	100
	GDP per capita (constant 2015 US$	2,193.9	5,647.1	9,688.5	10,228.3
South Africa	Electricity Access(%)	72.3	82.9	84.7	85
	GDP per capita (constant 2015 US$)	4505.9	5561.5	5639.9	5574.6
Egypt	Electricity Access(%)	97.7	99.5	100	100
	GDP per capita (constant 2015 US$	2610.5	3472.6	3831.20	3965.0
Nigeria	Electricity Access(%)	42.9	48.0	56.5	55.4
	GDP per capita (constant 2015 US$	1450.8	2403.6	2512.2	2502.7

Source: World Bank Development indicators,2021 as cited in Adamu and Mohammed (2022).

Higher access to electricity implies low transmission and distribution losses, evaluating the low level of electricity access that hampers economic growth in Nigeria as seen from table2 above is therefore important. It seems relevant to quantify the level of electricity losses especially the monetary quantification to reveal the wasted resources which could otherwise be use for productive purposes capable of boosting economic growth in the country. In order to further portray the nexus between electricity access and GDP per capita at glance, this study therefore, compared using graph, the relationship between access to electricity and GDP per capita among the countries as shown in fig3 using the data from table2.

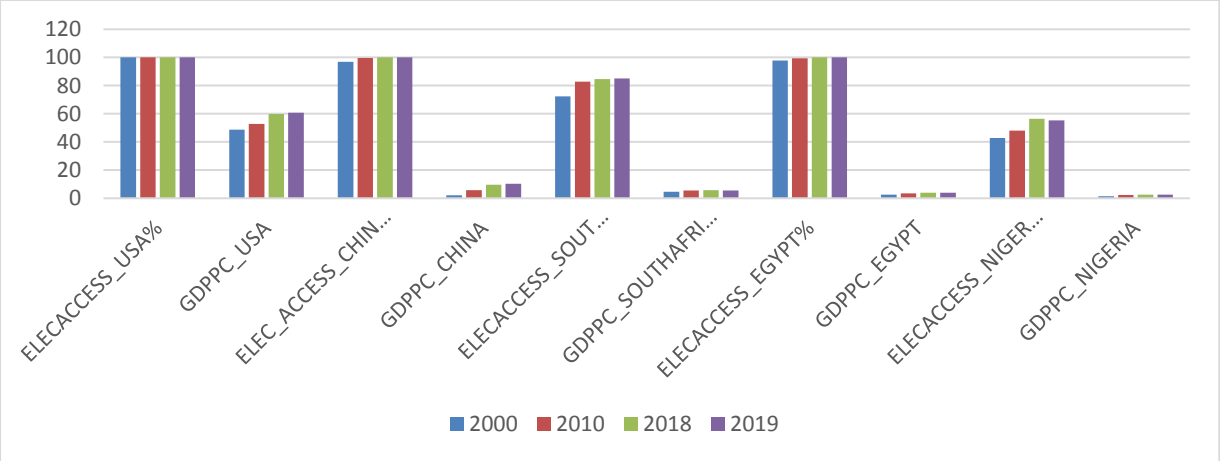

Fig. 3: Comparison of Electricity Access (%) and GDP per Capita (GDPPC) in '000 (Constant US $ 2015)

Nigeria exhibited both lowest (poor) access to electricity and GDP per capita from fig.3, It is demonstrated above that the poor electricity supplied is not unconnected with electricity transmission and distribution loses but with different magnitude. The latest information as of March, 2022, data from world development indicators revealed that Nigeria has the highest electricity transmission and distribution losses of 16. 11% for the year 2014, relative to 5.91% for USA, 5.47% for China, 8.39% for South Africa. 10.95% for Egypt (World Bank, 2022 b). These high rates of electricity losses in Nigeria aid in explaining the low access to electricity faced by especially the productive sectors of the economy which negatively affect the economic growth via reduction in available electricity for production.

To augment the World Bank data and make recent analysis, this study used available data for the year 2020 from Nigerian Electricity Regulatory Commission. The evaluated data shows huge average electricity transmission and distribution losses emanating from Nigerian DisCos that surpasses the global average of single digit by far more than 40% as estimated in table3, representing waste of resources that have associated negative spillover effects.
The quantification of the average rate of electricity losses emanating from all the existing DisCos in Nigeria serving different categories of consumers' tariff class (Residential, Commercial, Industrial, and Special consumers) in Nigeria is presented below.

Table3: Rate of Transmission and Distribution losses per DisCos in Nigeria, 2020

Month	Abuja	Benin	Eko	Enugu	Ibadan	Ikeja	Jos	Kaduna	Kano	P/Harcourt	Yola	**Average/month**
Jan/rate	37	53	28	52	52	24	65	57	43	61	65	44.75
Feb/rate	38	54	29	51	48	20	66	68	41	62	74	45.91667
Mar/rate	63	66	55	66	70	60	74	79	57	69	82	61.75
Apr/rate	50	60	28	51	60	27	70	81	60	70	76	52.75
May/rate	49	53	28	49	55	21	60	79	63	60	73	49.16667
Jun/rate	43	48	23	46	49	15	64	75	43	57	69	44.33333
Jul/rate	40	49	22	43	52	14	64	72	46	56	66	43.66667
Aug/rate	49	54	27	51	56	22	70	71	52	51	70	47.75
Sept/rate	33	61	40	62	64	38	70	83	53	66	79	54.08333
Oct/rate	-	-	-	-	-	-	-	-	-	-	-	0
Nov/rate	-	-	-	-	-	-	-	-	-	-	-	0

Dec/rate	-	-	-	-	-	-	-	-	-	-	-	0
Total	402	498	280	471	506	241	603	665	458	552	654	
Average/DisCo's	44.6667	55.3333	31.1111	52.3333	56.2222	**26.7778**	67	**73.8889**	50.8889	61.3333	72.6667	592.16/11=**53.83**
Monthly average					Jan to Sept.							444.167/9= **49.35 or**

Source: NERC, 2022. Except the totals and averages (ave).

Kaduna DisCo has the highest rate of distribution losses of 73.88% for the whole year, while Ikeja DisCo recorded lowest estimated losses of 26.77 among the eleven (11) DisCos. The estimated averages electricity distribution losses per distribution companies (DisCos) in Nigeria are 53.83%. Per month average loses is 49.35% for the nine (9) months where data are available and made up the sum total of the monthly loses. Both DisCos average losses and per month average losses are far above a single digit global average electricity transmission and distribution loses. This suggests the existence of inefficiencies and huge attributable economic losses which the study further quantified it in monetary value in subsequent part of this study.

Such energy losses are connected but not limited to negative; economic, social, health and political consequences. This study aimed at giving emphasis to the economic consequences of electricity transmission and distribution losses in Nigeria. This paper therefore, envisage to quantify the rate and monetary value of transmission and distribution losses from all the existing eleven (11) distribution companies (Dicos) in Nigeria for all the available months as of 2020 and based on data availability.

To the best of the authors' knowledge, given the reviewed literature, there is limited literature that quantify from all the DisCos such energy losses and their monetary values, Amadi et al., (2016) is one of such studies, but their study was limited to only three DisCos in Nigeria, while Eseosa and Promise (2015) focus on only the energy loss due to the 330Kv transmission network which was estimated to be over 4.4 billion Naira.

Thus, the literature suggests that causes, solutions and monetary quantification of these electricity losses received scanty attention especially on all the existing electricity transmission and distribution companies in Nigeria. This study intends to fill such gap for informed policy recommendation. Therefore, the objectives of this study are:

i) To identify the causes of electricity transmission and distribution losses emanating from Electricity Distribution Companies (DisCos) in Nigeria.

ii) To estimate the economic consequences from the Nigerian DisCos electricity transmission and distribution losses, and

iii) To explore the contribution of both GenCos and DisCos in Nigerian electricity supply.

2. Review of Relevant Literature

2.1 Causes of Electricity Transmission and Distribution losses

Although, based on 21st century level of development, there is no zero-electricity transmission and distribution losses globally, as such, it remained inevitable to record no electricity transmission and distribution losses, since globally, the unit of electric energy generated by power station does not match with the units distributed to the consumers of electricity.

Certain portions of the electricity units generated are lost in the distribution

network especially in the less developed Nigerian context that exhibited such rate above global single digit average. The literature accepted that the losses are due to but not limited to inefficiencies in electricity transmission and distribution usually cause by vandalization of transmission equipments and network by criminals, overloading, huge manpower deficit, lack of skilled distribution sub-station operators (manpower), electricity theft, a poor maintenance regime aggravated by lack of a centralized and automated control system among others, as captured in several studies (see, Senbanjo& Coker, 2013; Paul, et al., 2015; Usman, et al.,2015; Amadi et al., 2016 & Oyedepo, et al.,2018).

Some of the causes of inefficiencies in electricity supply in Nigeria and way out were proposed by empirical works, Paul, et al., (2015) posit that inefficient electricity supply in Nigeria and attendant consequences were identify to be associated with overloaded transmission network, frequent pipeline vandalization by Niger delta militant, increase in natural gas price that supplied the thermal engines. The authors suggested additional transmission network, renewable energy utilization (solar, wind, biomass e.t.c.). In addition, suggession on tapping the untapped renewable is captured in the work of Oyedepo, et al. (2018)

Study on the challenges and panaceas to power distribution losses in Nigeria revealed that *t*he major challenge in the distribution system is the high energy losses which are detrimental to the techno-economic benefits of the power systems. However, details of the distribution system challenges and the probable solutions have not been efficiently presented (Mohammed, et al., 2020).

2.2 Generated electricity and its economic consequences

Estimation of the electric energy generation for distribution was also conducted in an analysis and optimization of automated power distribution within Nigeria for the year 2019. Ofualagba and Ejofodomi (2020) had estimated 81,122 (MWh) energy generated by electricity generating companies (GenCos) using power optimization software as of October 1, 2019 for onward distribution to end users by DisCos, but without estimating the rate and proportion of the transmission and distribution losses in monetary terms, despite the importance of unveiling such important information for sake of policy direction toward improvement and energy losses minimization. The study unveiled transmission losses of 7.7% but the enormous distribution losses was in the range of 31% (Ikeja and Eko DisCos) to 77% (Kaduna DisCo) for February 2019.

Adams et al. (2020), findings from study of South African electricity transmission, distribution losses and economic growth showed long-run negative relationship between electricity losses and economic growth. Adamu and Maijama'a (2021) Opined that significant improvement in electric power supply is capable of reducing the cost of production and general prices; boost production and employment opportunities in Nigeria.

Komolafe *et al.,* (2020). Review of electrical energy losses in Nigeria provided an examination of the structure of the Nigerian electricity industry and technical review of factors responsible for the excessive losses (technical and non-technical) in the system. Their study further stated that over 50% of generated electric energy in Nigeria is recorded as losses.

Amadi et al., (2016) Made assessment of energy losses and cost implications in the Nigerian distribution network. The study used data points from 2011 to 2015 from three (3) electricity Distribution Companies (DisCos) in Nigeria drawn from three major industrial cities. Estimated electricity losses from Eko DisCo in Lagos was 108, 959.87 MWH, that of Kano Sabon Gari/Dakata substation was 149, 256 MWH, and for Port Harcourt Trans- Amadi network was

72,743.08. Their respective lost revenue from the electricity losses in naira (N) were N 2,434,164,02, N 3,538, 759 and N 1, 699,751,530 billion of naira. However, it focuses on only three Discos and restricted to industry.

Akuru and Okoro (2014) study on economic implications of constant power outages on SMEs in Nigeria. Apart from internal devastating effects on SMEs, they stated that constant power outages have a major connection with the trends of big companies closing or relocating from Nigeria. Eseosa and Promise (2015). Study the economic effects of technical and non-technical losses in Nigeria power transmission system. The study focuses on only the energy loss due to the 330Kv transmission network which was estimated to be to over 4.4 billion naira, the network was analyzed using Power World Simulator (PWS).

2.3 General studies on electricity in Nigeria

In general, there were several empirical papers on electricity ranging from: benchmarking analysis of electricity distribution (Filippini, et al., 2005); An overview of integrated power supply system: Solution to Nigeria's electricity problem (Senbanjo & Coker, 2013); Transforming the Nigerian power sector for sustainable development Usman, et al.,(2015); Electricity crisis in Nigeria: the way forward, Paul, et al., (2015) opined that epileptic electric energy supply dispel investors and delays development, suggesting utilization of renewable energy. On improving electricity access in Nigeria: obstacles and the way forward, Emodi and Yusuf (2015); Assessment of energy losses and cost implications in the Nigerian distribution network, Amadi et al., (2016); suggession on tapping the untapped renewable is captured in the work of Oyedepo, et al. (2018) Towards a sustainable electricity supply in Nigeria: the role of decentralized renewable energy system. Indeed, there is room for improvement from renewable, the total technically hydropower potential based on the country's river system is conservatively estimated to be about 11,000 MW of which only 19% is currently being tapped (Okafor& Joe-Uzuegbu, 2010) or developed.

All of reviewed literature gave various policy recommendations on how to improve the Nigerian electricity by identifying problems like shortage in gas supply to generating stations, vandalization of transmission equipment and network by criminals, overloading, huge manpower deficit, lack of skilled distribution sub-station operators (manpower), electricity theft, poor maintenance regime aggravated by lack of a centralized and automated control system among others. Specifically for Technical Losses such as : Lengthy Distribution lines, Inadequate Size of Conductors of Distribution lines, Installation of Distribution transformers away from load centers, Low Power Factor of Primary and secondary distribution system were retrieved from electricity engineering web (https://electrical-engineering-portal.com/), Very few pay detailed attention on estimating the monetary losses emanating from the DisCos in Nigeria, this is observed and need to be catered for.

3. Methodology

3.1 Data Sources and Method of Analysis

Survey of energy from Nigerian Electricity Regulatory Commission (NERC) was made and various secondary data on GenCos and DisCos for the analysis of the economic losses attributed to inefficiencies in electricity transmission and distribution in Nigeria were gathered. In addition, data on electricity hours per band were collected from database of International Centre for Investigative Reporting (ICIR, 2022). Finally, survey of related peer reviewed empirical works supplements the data sources with additional information used. Simple percentages were used in analysis of the data after deployment of all the needed

energy conversions for conformity with various energy data units available from the major source of the data for the study which is NERC.

3.2 Data presentation and Analysis of the Economic Losses (inefficiencies) of Electricity Transmission and Distribution in Monetary Values

Aside from the negative social, political and health consequences, major part of the economic loss were estimated in money equivalent of the energy loses based on the prevailing energy tariffs per Kwh in Nigeria. This unveiled the huge loses and draw the stake holders' attention to take steps toward curtailing the losses.

Thus, the cost of losses were calculated in the naira cost of the percentage of the ATC& C losses by taking minimum and maximum values of Naira rates or cost of electricity sold by the DisCos to consumers and the maximum and minimum hours allotted to the medium band (B and C with 12 to 16 hours of electricity made available). Before the computation, the study presents the current bands (A to E) together with the table of the Eleven (11) DisCos tariff per classes of consumer (Residential, Commercial, Industrial, Special and Street light) as presented below

Table4: Discos's Tariff in Naira Per Classes of Consumer, 2020

S/N	Discos	Price/Kwh	Residential	Commecial	Industrial	Special	Street Light(S/L)
1	ABUJA	MIN	4	29.7	28.64	28.38	21.75
		MAX	37.46	38.46	37.46	28.38	21.75
2	BENIN	MIN	4	34.47	35.18	32.59	35.81
		MAX	39.96	37.64	38.8	34.84	35.81
3	EKO	MIN	4	20.57	22.17	20.62	19.92
		MAX	26.21	29.19	29.69	20.62	19.92
4	ENUGU	MIN	4	23.27	27.4	23.18	22.3
		MAX	32.66	31.12	31.79	30.72	22.3
5	IBADAN	MIN	4	27.11	30.55	29.24	22.59
		MAX	40.48	38.09	41.15	29.24	22.59
6	IKEJA	MIN	4	21.13	23.85	22.57	16.34
		MAX	34.07	31.86	32.45	25.54	16.34
7	JOS	MIN	4	46.79	42.15	48.86	49.22
		MAX	50.35	49.98	46.66	48.86	49.22
8	KADUNA	MIN	4	22.48	24.58	25.47	29.61
		MAX	35.14	33.95	33.95	33.95	29.61
9	KANO	MIN	4	19.74	26.65	26.65	20.72
		MAX	35.53	33.55	34.54	26.65	20.72
10	P/HARCOUT	MIN	4	41.24	42.31	43.03	43.03
		MAX	52	50.2	50.2	52	43.03
11	YOLA	MIN	4	43.81	43.81	39.62	39.62

Author's Design based on several NERC data June, 2022

3.3: Understanding the Nigerian Electricity Tariff Classes for Analysis

There are five (5) major Tariff Classes each of which is divided into sub-classes based on a range of energy consumption. The 5 major tariff classes are as follows:

Tariff Class	Description
A Residential	A customer who uses his premise exclusively as a residence - house, flat, or multi-storied house.
B Commercial	A customer who uses his premise for any purpose other than exclusively as a residence or as a factory for manufacturing goods.
C Industrial	A customer who uses his premises for manufacturing goods including welding and ironmongery.
D Special	Customers such as agriculture and agro-allied industries, water boards, religious houses, government and teaching hospitals, government research institutes and educational establishments.
E Street Lights	Street Lights.

In addition, there are also bands based on hours of electricity made available and such hours affects all the tariff classes above. Band A (20 to 24 hours), Band B (16 to 20 hours), Band C (12 to 16 hours), Band D (8 to 12 hours), Band E (4 to 8 hours), thus simple analysis of the monetary economic consequences of ATC & C losses (inefficiencies) is estimated using all the different prior calculated values (Table 3).

4. Results and Discussion

Percentage of DisCos ATC & C losses is 53.83% from table 3, also an estimated total energy of 87,980 (MWh), which if divided by 24hours we get 3665.83 Mega Watt (MW) as the generated energy that is sent out to National grid by the generating companies (GenCos) in Nigeria (see table1) which is made available for the DisCos to distribute.

Therefore, proportion of energy losses is 47,359.634 MWh (53.83/100 x 87 980), which if converted to Mega Watt (MW) from Mega Watt hour (MWh) is 1973.318 MW (47359.634 MWh /24) energy Losses. Knowledge of the energy prices paid to DisCos by end users is needed which is in Kilo Watt hours (KWh) per Naira and also varies according to tariff class and bands. Thus, the MWh is converted to KWh by multiplying it with 1000 units, that is MWh x 1000 = KWh, as such the 47,359.634 MWh x 1000 is 47,359,634KWh which becomes the losses in such units. To estimate the monetary Naira equivalent of the ATC & C Losses for all the NERC tariff classes, the study takes minimum (MIN) and maximum (MAX) energy prices in Naira and used the medium hours band of 12 to 16 hours out of the five bands captured on Inside NERC's Electricity Tariff Regime retrieved from International Centre for Investigative Reporting (ICIR, 2022), the hours are multiplied by the calculated value of energy lost in KWh as shown below for all tariff classes.

Table 5: Monetary Quantification of the DisCos's Electricity Transmission and Distribution losses in Nigeria for: Residential, Commercial, Industrial, and Special Tariff Classes, 2020

RESIDENTIAL (R)

Discos	Price N/Kwh	Residential-R	Hours-H	Energy Lost (Kwh)-K	Losses in Naira (R*H*K)
Abuja	MIN	4	12	47359634	2273262432
	MAX	37.46	16	47359634	28385470234
Benin	MIN	4	12	47359634	2273262432
	MAX	39.96	16	47359634	30279855594
Eko	MIN	4	12	47359634	2273262432
	MAX	26.21	16	47359634	19860736114
Enugu	MIN	4	12	47359634	2273262432
	MAX	32.66	16	47359634	24748250343
Ibadan	MIN	4	12	47359634	2273262432
	MAX	40.48	16	47359634	30673887749
Ikeja	MIN	4	12	47359634	2273262432
	MAX	34.07	16	47359634	25816683686
Jos	MIN	4	12	47359634	2273262432
	MAX	50.35	16	47359634	38152921150
Kaduna	MIN	4	12	47359634	2273262432
	MAX	35.14	16	47359634	26627480620
Kano	MIN	4	12	47359634	2273262432
	MAX	35.53	16	47359634	26923004736
P/Harcourt	MIN	4	12	47359634	2273262432
	MAX	52	16	47359634	39403215488
Yola	MIN	4	12	47359634	2273262432
	MAX	55.47	16	47359634	42032622368

Source: Authors' Design based on several NERC data, 2022 and ICIR,2022

COMMERCIAL (C)

Discos	Price N/Kwh	Commecial-C	Hours-H	Energy Loss (Kwh)-K	Losses in Naira (C*H*K)
Abuja	MIN	29.7	12	47359634	16878973558
	MAX	38.46	16	47359634	29143224378
Benin	MIN	34.47	12	47359634	19589839008
	MAX	37.64	16	47359634	28521865980
Eko	MIN	20.57	12	47359634	11690252057
	MAX	29.19	16	47359634	22118843463
Enugu	MIN	23.27	12	47359634	13224704198
	MAX	31.12	16	47359634	23581308961

Discos	Price N/Kwh	Commecial-C	Hours-H	Energy Loss (Kwh)-K	Losses in Naira (C*H*K)
Ibadan	MIN	27.11	12	47359634	15407036133
	MAX	38.09	16	47359634	28862855345
Ikeja	MIN	21.13	12	47359634	12008508797
	MAX	31.86	16	47359634	24142047028
Jos	MIN	46.79	12	47359634	26591487298
	MAX	49.98	16	47359634	37872552117
Kaduna	MIN	22.48	12	47359634	12775734868
	MAX	33.95	16	47359634	25725753189
Kano	MIN	19.74	12	47359634	11218550102
	MAX	33.55	16	47359634	25422651531
P/Harcourt	MIN	41.24	12	47359634	23437335674
	MAX	50.2	16	47359634	38039258029
Yola	MIN	43.81	12	47359634	24897906786
	MAX	64.72	16	47359634	49041848200

Source: Authors' Design based on several NERC data, 2022 and ICIR,2022

INDUSTRIAL (D)

Discos	Price N/Kwh	Industrial-D	Hours-H	Energy Loss (Kwh)-K	Losses in Naira (D*H*K)
Abuja	MIN	28.64	12	47359634	16276559013
	MAX	37.46	16	47359634	28385470234
Benin	MIN	35.18	12	47359634	19993343089
	MAX	38.8	16	47359634	29400860787
Eko	MIN	22.17	12	47359634	12599557029
	MAX	29.69	16	47359634	22497720535
Enugu	MIN	27.4	12	47359634	15571847659
	MAX	31.79	16	47359634	24089004238
Ibadan	MIN	30.55	12	47359634	17362041824
	MAX	41.15	16	47359634	31181583026
Ikeja	MIN	23.85	12	47359634	13554327251
	MAX	32.45	16	47359634	24589121973
Jos	MIN	42.15	12	47359634	23954502877
	MAX	46.66	16	47359634	35356808359

Discos	Price N/Kwh	Industrial-D	Hours-H	Energy Loss (Kwh)-K	Losses in Naira (D*H*K)
Kaduna	MIN	24.58	12	47359634	13969197645
	MAX	33.95	16	47359634	25725753189
Kano	MIN	26.65	12	47359634	15145610953
	MAX	34.54	16	47359634	26172828134
P/Harcourt	MIN	42.31	12	47359634	24045433374
	MAX	50.2	16	47359634	38039258029
Yola	MIN	43.81	12	47359634	24897906786
	MAX	66.04	16	47359634	50042083670

Source: Authors' Design based on several NERC data, 2022 and ICIR,2022

SPECIAL (A)

Discos	Price N/Kwh	Special-A	Hours-H	Energy Loss (Kwh)-K	Losses in Naira (A*H*K)
Abuja	MIN	28.38	12	47359634	16128796955
	MAX	28.38	16	47359634	21505062607
Benin	MIN	32.59	12	47359634	18521405665
	MAX	34.84	16	47359634	26400154377
Eko	MIN	20.62	12	47359634	11718667837
	MAX	20.62	16	47359634	15624890449
Enugu	MIN	23.18	12	47359634	13173555793
	MAX	30.72	16	47359634	23278207304
Ibadan	MIN	29.24	12	47359634	16617548378
	MAX	29.24	16	47359634	22156731171
Ikeja	MIN	22.57	12	47359634	12826883273
	MAX	25.54	16	47359634	19353040838
Jos	MIN	48.86	12	47359634	27767900607
	MAX	48.86	16	47359634	37023867476
Kaduna	MIN	25.47	12	47359634	14474998536
	MAX	33.95	16	47359634	25725753189
Kano	MIN	26.65	12	47359634	15145610953
	MAX	26.65	16	47359634	20194147938
P/Harcourt	MIN	43.03	12	47359634	24454620612

Discos	Price N/Kwh	Special-A	Hours-H	Energy Loss (Kwh)-K	Losses in Naira (A*H*K)
	MAX	52	16	47359634	39403215488
Yola	MIN	39.62	12	47359634	22516664389
	MAX	52.83	16	47359634	40032151428

Source: Authors' Design based on several NERC data, 2022 and ICIR,2022

The estimated averages electricity transmission and distribution losses per distribution companies (DisCos) in Nigeria is 53.83%. This rate of transmission and distribution losses affects all the tariff plans per class of consumer and bands in Nigeria and year 2020 was used due to data availability for the generated energy sent to Discos.

Thus, as of 2020, the estimated averages electricity transmission and distribution losses from distribution companies (DisCos) in Nigeria is found to be 53.83%. The estimated monetary value of the losses per DisCo under each category of consumers (residential, commercial, industrial and special) relative to the minimum and maximum numbers of electricity supplied and the naira per kilowatt hour (N/KWh). Holding other tariff plan constant, with the assumption of all electricity value in monetary terms are channeled to; the very tariff plan, customer category and band under consideration for easy analysis. This enables monetary quantification of the value lost at minimum and maximum levels. Due to absence of information on the exact number of electricity hours supplied to each category of consumer, all the plans and bands were given equal chances independently, even though mix supply of the electricity is the reality, but there is so far no such information on number of exact hours supplied to each available tariff plan at a time. As such the estimated monetary losses were based on minimum and maximum hours separately.

Thus, starting with minimum estimated monetary values from transmission and distribution losses of the ***residential consumer tariff plan,*** there were estimated loss of two point two billion (N2. 27 bn) naira based on twelve (12) minimum hours of electricity supplied at N4/KWh, this is for all other DiscCos except the YolaDisCos with highest quantified monetary transmission and distribution losses worth forty-two point zero-three billion (N42. 03bn) naira calculated at 55.47/KWh given the maximum of 16 hours

As for the ***commercial consumer tariff plan***, Kano has the lowest quantified monetary distribution losses of eleven point two billion (N11. 2bn) Naira. This was based on N19.74 /KWh with the minimum of 12 hours for the commercial band. Yola received maximum of sixteen (16) hours at 64.72/KWh, this gives approximately forty-nine billion (N49.04bn) naira worth of transmission and distribution losses.

Lowest ***industrial consumer tariff plan*** as of year 2020 was 22.17/KWh for 12 hours in EKO distribution company, this amount to monetary value twelve point five billion (N12.5bn) naira. However, Yola has the highest quantified industrial monetary loss due to transmission and distribution inefficiency or losses amounting to fifty billion (N50.0bn) Naira based on maximum of 16 hours electricity supply at N66.04.

Lastly, for ***special consumer tariff category***, lowest quantified transmission and distribution losses is from EKO DisCo with eleven point seven billion (N11.7bn) naira based on N20.62/KWh for 12 hours, while the highest monetary equivalent from transmission and distribution losses based on N52.83/KWh for the maximum of 16

hours electricity supplied as at year 2020 goes to YolaDisCo, it had an estimated transmission and distribution losses worth forty billion (N40.0bn) naira.

5. Conclusion and Recommendations

The study found electricity transmission and distribution inefficiency or losses of about 1973.318MW electricity. The economic losses deduced for all the consumer tariff classes (Residential, Commercial, Industrial, Special and Street Light) relative to band hours supplied to end users of electricity, were computed based on the cumulative average transmission and distribution losses of the eleven DisCos in Nigeria.

The results gave billions of naira lost based on sub-division of the tariff classes (like R1, R2…D1, D2…, C1, C2… etc) of which this study used the minimum (MIN), and maximum (MAX) values in arriving at the monetary Naira values equivalent of the economic losses incurred due the transmission and distribution losses.

The highest transmission and distribution losses for: special consumer tariff is N40. 0bn, for industrial consumer tariff plan is N50. 0bn, for commercial consumer tariff plan is N49.04bn for residential consumer tariff plan is N42.03 all of which are from Yola DisCo.

While for the lowest transmission and distribution losses for the year 2020; on residential consumer tariff all DisCos have 2.27 billion worth of losses at least, except Yola with the highest of 49 bn.

Lowest estimated commercial losses were 11.2 billion from Kano, lowest industrial losses were 12.6 billion from ECO-LAGOS DisCo and finally, lowest transmission and distribution losses from special consumers tariff was 11.7 billion from ECO-LAGOS DisCo again.

Electricity transmission and distribution losses in Nigeria proved huge and resources lost, which if efficiently channeled is capable of having the positive multiplier effects in addressing series of glaring losses ranging from economic losses (fall in revenue from the energy sales, industries collapses, loss of gainful employment), social losses (unemployment related increase in social vices like kidnapping, robbery, theft, etc) health (increase in death rates due absence/shortages in power supply to power medical gadgets, damage to medicines that need refrigerators, light and power outages during surgery, etc.) and even political loses were politicians lose potential vote because of failure to fulfilled electricity campaign promises among others.

How to achieve that is by reversing the electricity losses and addressing the identified causes of the transmission and distribution losses in Nigeria, this can be done by addressing:

i. Vandalization of electricity equipment and network by criminals
ii. Reducing the overloading by providing enough electricity equipment
iii. Huge skilled manpower deficit be tackled by employing the skilled distribution sub-station operators based on merit
iv. Improved security for electricity theft
v. Regular and optimum maintenance regime and instituting a centralized and automated control system among others.

Finally, the paper recommends addressing the huge energy losses that is capable of giving positive; economic, health, political and social benefits via reversing the empirically identified causes of the electricity losses. There is also the need to explore and use the renewable energy potentials of Nigeria for more energy to the productive sectors of the economy. Related future studies should capture the cost of energy generation from the side of the generating companies and received by the distribution companies, this will further enable empirical researches like the input-output analysis of the electricity generation, transmission and distribution in Nigeria. If this information is obtained, Data Envelopment Analysis (DEA) can be

applied to unveil further useful information for policy making. Empirical estimation of the effects of electricity access on economic growth and development is another area for further study on time series or panel data which served as areas of improvement on this study.

References

Adams, S., Atsu, F., Klobodu, E. M., & Richmond, L. (2020). Electricity transmission, distribution losses and economic growth in South Africa. *Heliyon*, *6*(11), e05564.

Adamu, S., & Mohammed, R. (2022). Analysis of the Effects of Corruption and Electricity Access on Economic Growth in Nigeria. *African Scholar Publications & Research International,* Vol. 24 No.2

Adamu, S & Maijama'a, D (2021). Investigation of the Nexus among Unemployment, Inflation, Transport and Electric Energy Consumption in Nigeria. *Journal of Economics, Management & Social Science* Vol. 7 No.1: 61-79.

Akuru, U. B., & Okoro, O. I. (2014). Economic implications of constant power outages on SMEs in Nigeria. *Journal of Energy in southern Africa*, *25*(3), 47-61.

Amadi, H. N., Okafor, E. N., &Izuegbunam, F. I. (2016). Assessment of energy losses and cost implications in the Nigerian distribution network. *American Journal of Electrical and Electronic Engineering*, 4(5), 123-130.

Bhatti, S. S., Lodhi, M. U. U., ul Haq, S., Gardezi, S. N. M., Javaid, E. M. A., Raza, M. Z., & Lodhi, M. I. U. (2015). Electric power transmission and distribution losses overview and minimization in Pakistan. *International Journal of Scientific & Engineering Research*, *6*(4), 1108-1112.

Emodi, N. V., & Yusuf, S. D. (2015). Improving electricity access in Nigeria: obstacles and the way forward. *International Journal of Energy Economics and Policy*, 5(1), 335-351.

Eseosa, O., & Promise, E. (2015). Economic Effects of Technical and Non-Technical Losses in Nigeria Power Transmission System. *IOSR Journal of Electrical and Electronics Engineering Ver. I*, *10*(2), 2278-1676.

Filippini, M., Farsi, M., &Fetz, A. (2005, May). Benchmarking analysis in electricity distribution In European Regulation Forum on Electricity Reforms (pp. 3-4).

ICIR (2022). Inside NERC's Electricity Tariff Regime. https://www.icirnigeria.org/inside-nerc-electricity-tariff-regime/ retrieved 19th March, 2022 by 11:09 pm.

Komolafe, O. M., & Udofia, K. M. (2020). Review of electrical energy losses in Nigeria. *Nigerian Journal of Technology*, *39*(1), 246-254.

Mohammed, O. O., Otuoze, A. O., Salisu, S., Abioye, A. E., Usman, A. M., & Alao, R. A. (2020). The Challenges and Panaceas to Power Distribution Losses in Nigeria. *ARID ZONE JOURNAL OF ENGINEERING, TECHNOLOGY AND ENVIRONMENT*, *16*(1), 120-136. Retrieved from https://www.azojete.com.ng/index.php/azojete/article/view/183

NERC (2022[a]). Energy Sent Out to Grid by each GenCo, in 2020: Average daily energy (Mwh) sent out by stations, retrived from https://nerc.gov.ng/index.php/library/industry-statistics/generation/549-energy-sent-out-to-grid-by-each-genco, 18th March,2022 by 10: 47 am.

NERC (2022). https://nerc.gov.ng

Ofualagba, G. and Ejofodomi, O. (2020). Analysis and Optimization of Automated Power Distribution Within Nigeria. *American Journal of Modern Energy*, 5(5), 74.

Okafor E.N.C. and Joe-Uzuegbu (2010). Challenges to development of renewable energy for electricity power sector in Nigeria. *International journal of academic research*, 2:2 211-216.

Oyedepo, S. O., Babalola, O. P., Nwanya, S. C., Kilanko, O., Leramo, R. O., Aworinde, A. K., ... & Agberegha, O. L. (2018). Towards a sustainable electricity supply in nigeria: the role of decentralized renewable energy system. European Journal of Sustainable development research, 2(4), 40.

Paul, O., Albert, O., & Adeiza, A. (2015). Electricity crisis in Nigeria: the way forward. *American Journal of Renewable and Sustainable Energy*, 1(4), 180-186

Senbanjo, A. A., & Coker, J. O. (2013). An overview of integrated power supply system: Solution to Nigeria's electricity problem. *Journal of Applied and Natural Science*, 5(1), 268-273.

The World Bank (2020). Nigeria to Keep the Lights on and Power Its Economy. https://www.worldbank.org/en/new/press-release/2020/06/23/nigeria-to-keep-the-light-on-and-power-its-economy

Ugwoke, B., Gershon, O., Becchio, C., Corgnati, S. P., & Leone, P. (2020). A review of Nigerian energy access studies: The story told so far. *Renewable and Sustainable Energy Reviews*, 120, 109646.

Usman, Z. G., Abbasoglu, S., Ersoy, N. T., &Fahrioglu, M. (2015). Transforming the Nigerian power sector for sustainable development. *Energy Policy*, 87, 429-437.

World Bank (2022). World Development Indicators. www.Data.worldbank.org

World Bank (2022 b). Electric power transmission and distribution losses (% of output).