Optimization of Electric Power Distribution in Ilorin Metropolis

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ABSTRACT

Electricity supply to the people in Ilorin has been faced with a lot of inadequacies and often met with several complains by the consumers (IBEDC 2016). This research optimized the efficiency level of Ibadan Electricity Distribution Company (IBEDC) in Ilorin using Linear Programming approach. Newton Gregory Interpolation Method was used to develop an efficiency distribution model. MATLAB and MAPLE were used for numerical computation of results. The findings reveled that IBEDC in Ilorin, has not been functioning to the best of their capacity. The study was able to predict future efficiency levels for the next five years (2022-2026) in the following order 72.16%, 75.84%, 80.22%, 93.43% and 93.43%. Based on this work, it is recommended that IBEDC in Ilorin need to ensure effective distribution of energy received from the Generating Companies (GENCOS), devoid of unnecessary lost. Government and policy makers are also advised to engage in an effective, verifiable and accountable investment towards ensuring allocated resources geared towards boosting power generation are judiciously used for targeted purposes to ensure and measure the growth in the power sector with time.

Keywords: Electricity, Linear Programming, Power Distribution, Optimization.

I. INTRODUCTION

The significance of electricity or steady power supply in any modern society today cannot be over emphasized because it is the most versatile form of energy which plays a very important role in the social and economic prosperity (Adekoya and Jeremiah 2019, Addeh 2021). Nwokoye et al (2017) Submitted that electricity is one of the most important blessings that science has given to mankind. It is important to our civilization, security, job creation and other aspects like health care systems (Simon 2021). It is often converted easily to numerous forms of energy for example lighting, heating, cooling, refrigeration and for operating appliances, computers, electronics, machinery, and other public transportation systems (Bhalla et al 2003). Olatunji et al (2018) observed that electricity is normally generated from conventional energy sources like fossil fuels (natural gas, coal), water power (hydro and pumped storage), biotic, fission etc., or non-conventional (renewable) energy sources like solar, wind, water power (tidal and waves), biofuels (biomass and biogas), geothermal, ocean thermal, or combination of both sources.

In Nigeria, a better part of her electricity is generated largely from natural or primary conventional energy sources like fossil fuels (gas), hydro power, which is unfortunately, grossly inadequate (Adenikinju 2005). Presently, the total electricity output in Nigeria is below 5,000MW despite having the capacity to generate up to 12,000MW which is insufficient for a rustic of over 195 million people that require about 40,000MW or more to sustain the essential needs of the population (Tena 2021). The electricity sector in Nigeria, as the biggest economy in Africa generates, transmits and distribute megawatts of electrical power that is significantly less than what is needed to meet basic household and industrial needs (Oladipo 2018). South Africa, the second largest economy with a 60 million population is generating 58,000 Megawatts. Egypt, the third largest economy with a 100 million population is generating 55,000 Megawatts (USAID 2021). The amount of electrical power generated usually fall as low as 1,750MW as a result of electricity theft from unauthorized connections, power loss in transmission, vandalism of kit, lack of proper maintenance of transformer, poor management and corruption among others are some of the reasons for sub-optimal production of electricity in Nigeria (Okpare and Okreghe 2020)

II. POWER DISTRIBUTION IN KWARA STATE

Kwara is a state in the Middle Belt region of the Federal Republic of Nigeria, bordered to the east by Kogi State, to the north by Niger State, and to the south by Ekiti, Osun and Oyo States, while its western border makes up part of the international border with Benin Republic (IBEDC 2016). Kwara has three Senatorial District, Kwara North, South and Kwara Central. Ilorin, the state capital of Kwara State has 20 political wards which comprise three Local Government Areas, Ilorin East, Ilorin West and Ilorin South with a total population of about 1 million people (IBEDC 2016). The Kwara region of Ibadan Electricity Distribution Company (IBEDC) comprising Challenge district, Omu- Aran, Jebba, Baboko, parts of Ekiti, parts of Kogi, parts of Oshogbo and Niger with total distribution output not more than 131.4 megawatts, is said to require at least 270 megawatts of electricity to ensure 24 hours power supply in Ilorin, the Kwara State capital, and its environs, according to (IBEDC 2016). The company had struggled over the years to deliver efficient electricity supply to both individual and industrial customers known as Maximum Demand customers (MDs) and Non-Maximum Demand customers (Non-MDs) in the city but due to certain constraints the electricity distribution has not been able to meet the efficient demand of the entire population in Ilorin metropolis (Tena 2021) Poor power supply situation in Ilorin could easily be blamed on: Inadequate generation of power supply to the state, power loss, energy theft, household energy consumption pattern and occasional system failures (Ejor 2021). According to Vanguard News published on the 18th March 2019, thirty communities in Ilorin, Kwara State capital on one Monday morning staged a peaceful protest over total blackout being experienced in the affected communities over the last six months. They said the last time they were supplied power by IBEDC, in the affected communities was on November 20, 2018. The affected communities are Alore, Oloje, Ita-Merin, Banni, Abayawo, Gunniyan, Anifowose, Pakata, Alfa-Yahaya, Oke-Agodi, Agbarigidoma, Gaa Oke-Idi emi, Ogidi, Temidire, Others are Abemi, Adeta, Aiyekale, Ifesowapo, Sakele, Olomoda, Albarika, Iberuoluwa, Ajegunle, Gaa-Osibi, Ifedayo,among others (IBEDC 2016).

III. MATERIALS AND METHODS

3.1. Data Description

This study utilized data set collected from IBEDC Unit of Ilorin Metropolis, Kwara State Nigeria. The data contained a record of the total amount of energy received and energy billed on a monthly basis from January 2015 to December 2021. It also included the billing details of various districts in Ilorin Metropolis. MATLAB and MAPLE were used for numerical computation of results.

3.2. Research Methodology

3.2.1. Linear Programming Method

The general linear programming problem is of the form:

$$Optimize\ Z = c_1x_1 + c_2x_2 + c_3x_3 + \cdots c_nx_n\ (Objective\ function)$$

$$subject\ to\quad a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + \cdots + a_{1n}x_n * b_1$$

$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + \cdots + a_{2n}x_n * b_2$$

$$a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + \cdots + a_{3n}x_n * b_3$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + a_{m3}x_3 + \cdots + a_{mn}x_n * b_m \qquad (3.1)$$

$$where\ x_1, x_2, x_3 \cdots x_n \geq 0$$

$$and * means\ <, >, \leq, \geq\ or = sign$$

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Note: In this research work, we denote all the parameters in the general formula as follows

c_i = Energy billed for the years under review

x_i =Efficiency in power distributed for the years under review

a_{ij} = Energy billed for the months in the years under review

b_{ij} = Energy received for the month in the years under review

				ININCOMING VARIABLES								
OUTGOING VARIABLES	BV	CB	x_1	x_1	x_1	$\cdots$	x_n	x_{n+1}	x_{n+2}	$\cdots$	x_{n+m}	xB
	x_{n+1}	0	a_{11}	a_{12}	a_{13}	$\cdots$	a_{1n}	0	0	$\cdots$	0	$\vdots$
	x_{n+2}	0	a_{21}	a_{22}	a_{23}	$\cdots$	a_{2n}	0	0	$\cdots$	0	$\vdots$
	x_{n+3}	0	a_{31}	a_{32}	a_{33}	$\cdots$	a_{3n}	0	0	$\cdots$	0	$\vdots$
	$\vdots$											
		z_j	0	0	0							
		c_j	c_1	c_2	c_3							
		δ_j	$= z_j - c_j$									

Table 3.1: General Simplex Table. Source [6]

3.2.2. Newton Gregory Forward Difference Interpolation Method

Suppose the function $y = f(x)$ is known at $(n + 1)$ equispaced points $x, x_1, \cdots, x_n$ and they are $y_0, y_1, \cdots, y_n$ respectively i.e., $y_i = f(x_i), i = 0, 1, \cdot\cdot\cdot, n$. Let $x_i = x_0 + i_h$ and $u = \frac{x - x_1}{h}$ where h is the step length [5]. The Newton Gregory Forward Interpolation formula is

$$y = f(x) = y_0 + u\Delta y_0 + \frac{u(u-1)}{2!}\Delta^2 y_0 + \cdots + \frac{u(u-1)\cdots(u-\overline{n-1})}{n!}\Delta^n y_0 \qquad (3.2)$$

3.2.3 Newton Gregory Backward Difference Interpolation Method

This formula is useful when the value of $f(x)$ is required near the end of the table. h is called the step length of the difference and $u = \frac{(x-an)}{h}$, $f(a + nh - uh) = f(a + nh) + u\nabla f(a + nh) + \frac{u(u+1)}{2}!\Delta^2 f(a + nh) + \cdots + \frac{(u(u+1)\cdots(u+n-1))}{n}!\Delta^n f(a + nh)$ (3.3)

Difference Table

As before, suppose that we have a set of values of an unknown function $y_1, y_2, y_3, \cdots, y_n$

corresponding to a set of valves of the (known) independent variable $x_1, x_2, x_3, \cdots, y_n$

where $x_1 < x_2 < x_3, \cdots < x_n$ To obtain the value of y corresponding to any x (where $x_1 < x_2 < x_3, \cdots < x_n$) will be based on the values of the $n + 1$ data entries. Hence, $y_{r+1} - y_r$ is called the first difference of y_r denoted by $\Delta y_r : \Delta y_r = y_{r+1} - y_r$. Similarly, $\Delta y_{r+1} - \Delta y_r$ is the second difference: $\Delta^2 y_r = y_{r+1} - \Delta y_r$ For example, $\Delta^2 y_0 = \Delta y_1 - \Delta y_0 = (y_2 - y_1) - (y_1 - y_0) = y_2 - 2y_1 + y_0$. Similarly, $\Delta^2 y_1 = \Delta y_2 - \Delta y_1 = (y_3 - y_2) - (y_2 - y_1) = y_3 - 2y_2 + y_1$. In general term $\Delta^2 y_r = y_{r+2} - 2y_{r+1} + y_1$ $\quad r = 0,1,2, \cdots n - 2$.

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The third difference: $\Delta^3 y_r = y_{r+3} - 3y_{r+2} + 3y_{r+1} y_r \qquad r = 0,1,2,\cdots n-3$

Clearly, successive differences can be calculated and put into a table such as shown below

x	y	Δ_y	${\Delta^2}_y$	${\Delta^3}_y$	${\Delta^4}_y$	${\Delta^5}_y$
x_0	y_0	Δ_{y_0}				
			${\Delta^2}_{y_0}$			
$x_1(= x_0 + h)$	y_1	Δ_{y_1}		${\Delta^3}_{y_0}$		
					${\Delta^4}_{y_0}$	
$x_2(= x_0 + 2h)$	y_2	Δ_{y_2}				${\Delta^5}_{y_0}$
					${\Delta^4}_{y_1}$	
$x_3(= x_0 + 3h)$	y_3	Δ_{y_3}		${\Delta^3}_{y_2}$		
			${\Delta^2}_{y_3}$			
$x_4(= x_0 + 4h)$	y_4	Δ_{y_4}				
$x_5(= x_0 + 5h)$	y_5					

Table 3.2: General Forward Difference Table. Source [5].

IV. RESULTS AND DISCUSSIONS

In this section, the results of our findings are presented.

From the raw data collected from IBEDC unit Ilorin for the years under review it was observed that the amount of energy that is being distributed on a monthly basis is usually lesser than the amount of total energy received.

TOTAL ENERGY RECEIVED: 1548.2266

TOTAL ENERGY BILLED: 1179.32025

The efficiency in Power distribution was calculated using the formula:

$$ED = \frac{E_B}{E_R} \times 100 \qquad (4.1)$$

Where

E_D is efficiency of distribution

E_B is energy billed

E_R is energy received.

MATLAB was employed for the optimization process, with MAPLE used for estimation of the forward and backward difference interpolations.

YEAR/MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2015	78.8524	94.4132	94.9621	91.8377	90.5824	90.5824	75.6261	88.2795	91.9991	95.2961	92.5816	97.0761
2016	86.7526	80.7016	86.2481	89.8776	93.0758	91.3563	95.0034	95.2729	90.8887	88.9236	94.9526	9.5178
2017	74.39.	93.43	76.46	74.87	83.52	56.87	68.94	76.94	80.81	67.63	60.93	60.16

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	54	43	39	06	64	54	15	50	25	89	75	42
2018	89.9393	82.6591	67.9224	66.6525	66.0791	60.0984	81.2168	75.5864	53.2352	49.9026	81.2168	63.9991
2019	81.0861	80.8813	80.9789	80.9789	81.6104	81.0038	81.2267	80.7794	80.7271	80.5303	82.1650	81.0166
2020	81.4281	81.4563	79.6617	79.6616	48.4061	49.6413	56.1269	54.9873	55.5556	58.7715	66.5865	64.6139
2021	64.9146	66.1039	76.4639	76.4639	75.2445	62.8382	65.2909	56.9676	57.3422	68.2770	57.5157	60.3609

Table 4.1: Efficiency in Power Distribution Table

AVERAGE EFFICIENCY (%)	
2015	90.17
2016	90.31
2017	72.92
2018	69.88
2019	81.08
2020	64.74
2021	65.65

Table 4.2: Average Efficiency in Power distribution in Ilorin

YEAR/MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
2015	3.4816	1.01824	0.84298	1.33433	2.19597	1.64236	4.33529	2.18884	1.37004	0.87229	1.27029	0.50461
2016	2.36597	3.46597	2.73325	1.91249	1.29106	1.70433	0.9804	0.85659	1.59458	2.03713	1.00861	1.78051
2017	4.63972	1.1309	3.5874	4.60063	3.19191	7.89515	4.84254	3.59466	3.80204	6.1298	8.37132	8.27276
2018	1.99355	3.36786	5.31543	6.2512	6.14668	8.08544	3.73325	4.21081	8.11814	9.39106	3.73325	6.74859
2019	3.5816	3.50024	3.37298	3.40433	3.26587	3.47046	3.46249	3.68484	3.7614	3.30529	3..17849	3.76161
2020	3.03524	3.64314	4.12124	9.2526	9.849966	9.78040	8.11465	8.15659	8.0000	6.23717	6.00861	6.57051
2021	7.28624	6.56769	3.5874	4.60063	4.29742	6.15792	4.85287	8.50192	8.19647	5.48087	9.22908	8.57606

Table 4.3: Unused Electricity Power in Ilorin

AVERAGE UNUSED POWER (%)	
2015	1.76

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2016	1.81
2017	5.01
2018	5.60
2019	3.48
2020	6.91
2021	6.44

Table 4.4: Average Unused Power in Ilorin

From table 4.1 and table 4.3 the Linear Programming Problem is formulated as follows:

$$Max\ Z = 188.9259x_1 + 203.5588x_2 + 159.7029x_3 + 157.7134x_4 + 180.4172x_5 + 143.0604x_6 + 143.6087x_7 \quad (4.1)$$

Subject to:

$$13.35462x_1 + 15.39392x_2 + 13.48093x_3 + 17.82168x_4 + 15.35462x_5 + 16.18402x_6 + 13.48093x_7 \leq 132.3108 \quad (4.2)$$

$$17.20766x_1 + 4.49392x_2 + 16.14219x_3 + 16.05362x_4 + 14.80766x_5 + 16.00306x_6 +12.80824x_7 \leq 130.2146 \quad (4.3)$$

$$15.88982x_1 + 17.14219x_2 + 11.65469x_3 + 11.25512x_4 + 14.3535982x_5 + 16.14219x_6 + 11.65469x_7 \leq 121.6592 \quad (4.4)$$

$$15.01319x_1 + 16.98123x_2 + 13.70715x_3 + 12.49441x_4 + 16.01319x_5 + 12.17799x_6 + 13.70715x_7 \leq 131.4505 \quad (4.5)$$

$$15.49392x_1 + 17.35455x_2 + 16.1818402x_3 + 11.97397x_4 + 14.49392x_5 + 9.241354x_6 + 13.06217x_7 \leq 128.0428 \quad (4.6)$$

$$15.79683x_1 + 18.01319x_2 + 10.41263x_3 + 12.17799x_4 + 14.79873x_5 + 9.641097x_6 + 10.41263x_7 \leq 129.9891 \quad (4.7)$$

$$15.45123x_1 + 18.64108x_2 + 10.74914x_3 + 16.14219x_4 + 14.98123x_5 + 10.38106x_6 + 9.128671x_7 \leq 123.8748 \quad (4.8)$$

$$16.48648x_1 + 17.2640x_2 + 11.99702x_3 + 13.05927x_4 + 15.48648x_5 + 9.96405x_6 + 11.25512x_7 \leq 126.7139 \quad (4.9)$$

$$15.75350x_1 + 15.84914x_2 + 16.01319x_3 + 19.2413x_4 + 15.75350x_5 + 74914x_6 + 10.74914x_7 \leq 128.0021 \quad (4.10)$$

$$17.67128x_1 + 16.35465x_2 + 12.80824x_3 + 9.354546x_4 + 13.67128x_5 + 9.354546x_6 + 11.79641x_7 \leq 124.4626 \quad (4.11)$$

$$15.83190x_1 + 18.97397x_2 + 13.05927x_3 + 16.14219x_4 + 14.64319x_5 + 11.97397x_6 + 12.49441x_7 \leq 135.9398 \quad (4.12)$$

$$16.75322x_1 + 16.99702x_2 + 12.49441x_3 + 11.99702x_4 + 16.05362x_5 + 11.99702x_6 + 13.05927x_7 \leq 135.5662 \quad (4.13)$$

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Where

$x_1, x_2, x_3, x_4, x_5, x_6, x_7 \geq 0 \ \ x_{i,} \ i = 1(1)7$, denote the efficiency level of electricity distribution by the IBEDC Ilorin.

Adding the slack variables we have*:*

Max Z $= 188.9259x_1 + 203.5588x_2 + 159.70291x_3 + 157.713x_4 + 180.4172x_5 + 143.0604x_6 + 143.6087x_7$ (4.14)

Subject to:

$13.35462x_1 + 15.3939x_2 + 13.48093x_3 + 17.82168x_4 + 15.35462x_5 + 16.18402x_6 + 13.48093x_7 + x_8 = 132.3108$ (4.15)

$17.20766x_1 + 4.49392x_2 + 16.14219x_3 + 16.05362x_4 + 14.80766x_5 + 16.00306x_6 + 12.80824x_7 + x_9 = 130.2146$ (4.16)

$15.88982x_1 + 17.14219x_2 + 11.65469x_3 + 11.25512x_4 + 14.3535982x_5 + 16.14219x_6 + 11.65469x_7 + x_{10} = 121.6592$ (4.17)

$15.01319x_1 + 16.98123x_2 + 13.70715x_3 + 12.49441x_4 + 16.01319x_5 + 12.17799x_6 + 13.70715x_7 + x_{11} = 131.4505$ (4.18)

$15.49392x_1 + 17.35455x_2 + 16.1818402x_3 + 11.97397x_4 + 14.49392x_5 + 13.062x_6 - 7x_7 + x_{12} = 128.0428$ (4.19)

$15.79683x_1 + 18.01319x_2 + 10.41263x_3 + 12.17799x_4 + 14.79873x_5 + 9.641097x_6 + 10.41263x_7 + x_{13} = 129.9891$ (4.20)

$15.45123x_1 + 18.64108x_2 + 10.74914x_3 + 16.14219x_4 + 14.98123x_5 + 10.38106x_6 + 9.128671x_7 + x_{14} = 123.8748$ (4.21)

$16.48648x_1 + 17.26406x_2 + 11.99702x_3 + 13.05927x_4 + 15.48648x_5 + 9.964057x_6 + 11.25512x_7 + x_{15} = 126.7139$ (4.22)

$15.75350x_1 + 15.84914x_2 + 16.01319x_3 + 19.24135x_4 + 15.75350x_5 + 74914x_6 + 10.74914x_7 + x_{16} = 128.0021$ (4.23)

$17.67128x_1 + 16.35465x_2 + 12.80824x_3 + 9.354546x_4 + 13.67128x_5 + 9.354546x_6 + 11.79641x_7 + x_{17} = 124.4626$ (4.24)

$15.83190x_1 + 18.97397x_2 + 13.05927x_3 + 16.14219x_4 + 14.64319x_5 + 11.97397x_6 + 12.49441x_7 + x_{18} = 135.9398$ (4.25)

$16.75322x_1 + 16.99702x_2 + 12.49441x_3 + 11.99702x_4 + 16.05362x_5 + 11.99702x_6 + 13.05927x_7 + x_{19} = 135.5662$ (4.26)

The slack variables are $x_8, x_9, x_{10}, x_{11}, x_{12}, x_{13}, x_{14}, x_{15}, x_{16}, x_{17}, x_{18}, and\ x_{19} \geq 0.$

The Objective function (Z) was derived from the sum of energy billed for the years under review (C_i) while the unknown variable (X_i) stands for the efficiency of the distribution. We have 12 unique constraints, which simply cover all months in a year for all the years under review. The constraints were formulated from energy billed and energy received for the months in the years under review.

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BV	CB	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	x_{19}	XB	Ratio
x_8	0	13.5462	15.49392	13.48093	17.82168	15.35462	16.18402	13.48093	1	0	0	0	0	0	0	0	0	0	0	0	132.3108	8.5395
x_9	0	17.20766	4.49392	16.14219	16.05362	14.80766	16.00306	12.80824	0	1	0	0	0	0	0	0	0	0	0	0	130.2146	28.9757
x_{10}	0	15.88982	17.14219	11.65469	11.25512	14.35982	16.14219	11.65469	0	0	1	0	0	0	0	0	0	0	0	0	121.2146	7.0971
x_{11}	0	15.01319	16.98123	13.70715	12.49441	16.01319	12.17799	13.70515	0	0	0	1	0	0	0	0	0	0	0	0	131.4505	7.7407
x_{12}	0	15.49392	17.35455	16.18402	11.97397	14.49392	9.241354	13.06207	0	0	0	0	1	0	0	0	0	0	0	0	128.0428	7.3781
x_{13}	0	15.79683	18.01319	10.41263	12.17799	14.79873	9.641079	10.41263	0	0	0	0	0	1	0	0	0	0	0	0	129.9891	7.216
x_{14}	0	13.45123	18.64108	10.74914	16.14219	14.98123	10.38106	9.128671	0	0	0	0	0	0	1	0	0	0	0	0	123.8748	6.6453
x_{15}	0	16.48648	17.26406	11.99702	13.05127	15.48648	9.964057	&11.25512	0	0	0	0	0	0	0	1	0	0	0	0	126.7139	7.3398
x_{16}	0	15.7535	15.84914	16.01319	19.241354	15.7535	10.00000	10.74914	0	0	0	0	0	0	0	0	1	0	0	0	128.0021	8.0763
x_{17}	0	17.67128	16.35465	12.80824	9.354546	13.67128	9.354546	11.79641	0	0	0	0	0	0	0	0	0	1	0	0	124.4626	7.6102
x_{18}	0	15.8319	18.97397	13.05927	16.14219	14.64319	11.97397	12.49441	0	0	0	0	0	0	0	0	0	0	1	0	135.9398	7.1645
x_{19}	0	16.75322	15.99702	12.49441	11.99702	16.05362	11.99702	13.05927	0	0	0	0	0	0	0	0	0	0	0	1	135.5662	7.9759
	z_j	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
	c_j	188.9259	203.5588	159.7029	157.7134	180.4172	143.0604	143.6087	0	0	0	0	0	0	0	0	0	0	0	0		
$\delta_{j=}(z_j - c_j)$		-188.9259	-203.5588	-159.7029	-157.7134	-180.4172	-143.0604	-143.6087	0	0	0	0	0	0	0	0	0	0	0	0		

Table 4.5: Simplex Table

Hence, the efficiencies are

$$2015(x_1) = 0.298345760955721$$

$$2016(x_2) = 2.189705298436050$$

$$2017(x_3) = 0.951006449110309$$

$$2018(x_4) = 0.019508936363763$$

$$2019(x_5) = 4.066217803252357$$

$$2020(x_6) = -0.000000000016371$$

$$2021(x_7) = 0.831320172948608$$

Therefore,

$$Max\ Z = 1510.05467 \quad (4.27)$$

The indicated x-values represent the efficiency levels for the years under review from 2015 to 2021, which shows that, IBEDC in Ilorin can perform better than their current outputs. Their performance in 2016 and 2019 have the highest efficiency levels, one of the factors responsible for this was there were significantly lesser amount of unutilized power in those two years in comparison to the rest of the years in the study. The result however, indicated a low level of efficiency in the year 2020, due to an exorbitant rate of unutilized power in the year and some other logistics and management problems according to a report by the IBEDC Kwara Region on one of their social media handle on the 21st September, 2020 (IBEDC, 2020). We observed that the amount of energy that is being distributed on a monthly basis is usually lesser than the amount of total energy received by the distribution unit. The result shows that the maximum solution obtained (equation 4.27) is higher than the total amount of energy used from the available energy, that is total energy billed for the years under review by the IBEDC unit of Ilorin Metropolis. The difference is about (330.7344MW) which is enough to take care of at least another three years based on the capacity with which they are functioning presently.

Using Newton Gregory Backward difference interpolation formula we derived the prediction model from Table 4.2 by expanding the equation using MAPLE.

Hence, the prediction model is given as

$$y(x) = 0.1915555556x^6 - 5.091333334x^5 + 53.16680555x^4 - 275.248333x^3 + 731.4616389x^2 - 920.3478334x + 481.5100000 \quad (4.29)$$

Equation (4.29) is the prediction model of power distribution in Ilorin Metropolis.

Using the Newton Backward Difference Interpolation formula we derived the lost in electrical power model from Table 4.4. Hence, the model is given as

$$y(x) = 0.03995833333x^6 - 1.0563750000x^5 + 9.513541666x^4 - 42.03145833x^3 + 95.44650000x^2 - 105.0621667x + 49.59000000 \quad (4.30)$$

The Efficiency Model Curve of Power Distribution in Ilorin Metropolis

Power Distribution Efficiency

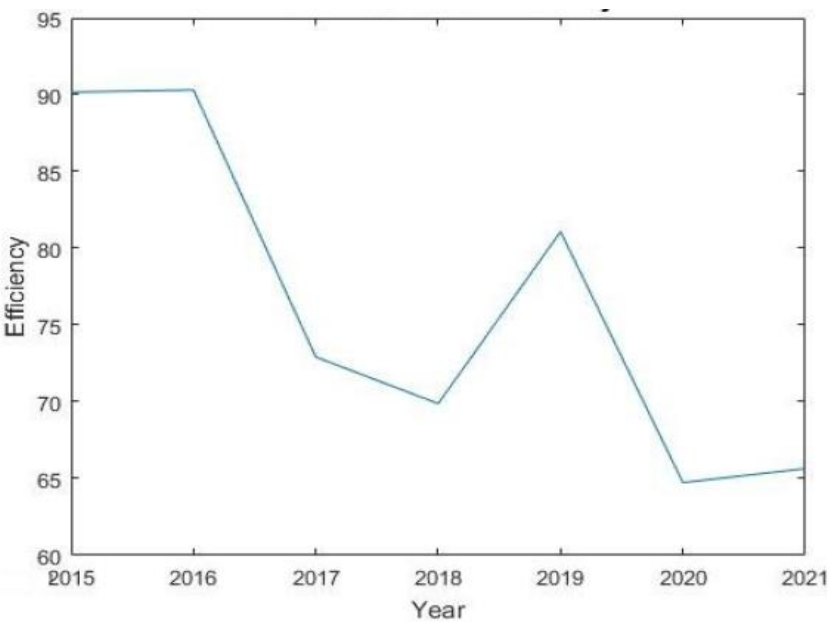

Figure 4.1: The efficiency model of Power Distribution in Ilorin

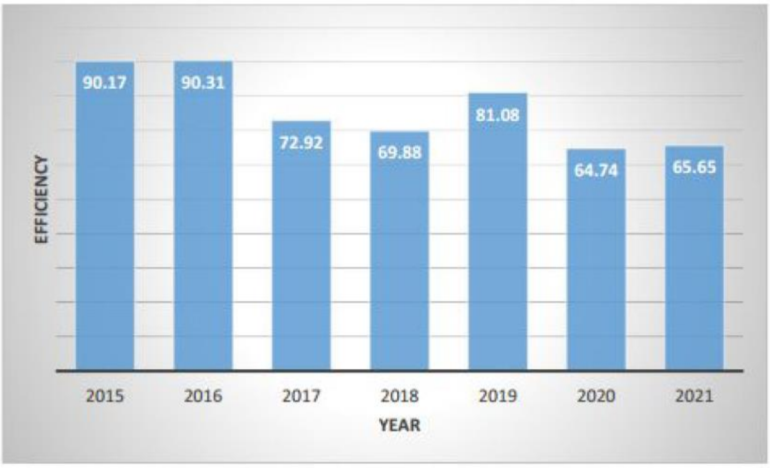

Figure 4.2: The Efficiency Chart of Power Distribution in Ilorin

From the curve in Figure 4.1 and chart in Figure 4.2 it was observed that between 2015 and 2019, the efficiency level was far above average based on the amount of energy received by IBEDC unit in Ilorin Metropolis and was judiciously distributed.

It was also observed that the efficiency level in year 2020 was the lowest due to a very high rate of unutilized power received by the distribution unit. Other factors that also influenced this include poor maintenance system, energy theft and loss in transmission as illustrated in Figure 4.3.

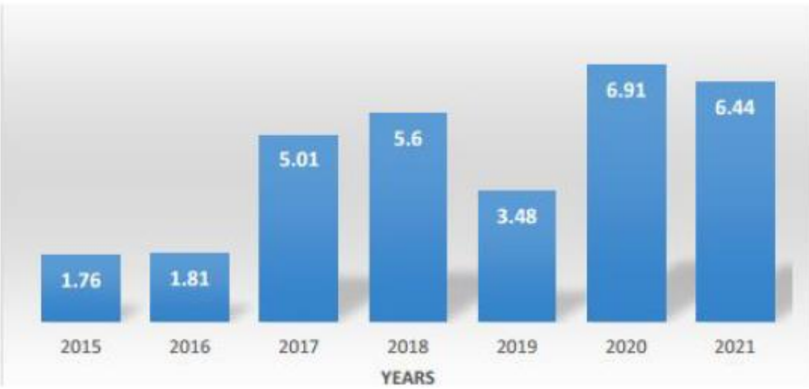

Figure 4.3: Lost in electrical power in Ilorin Metropolis

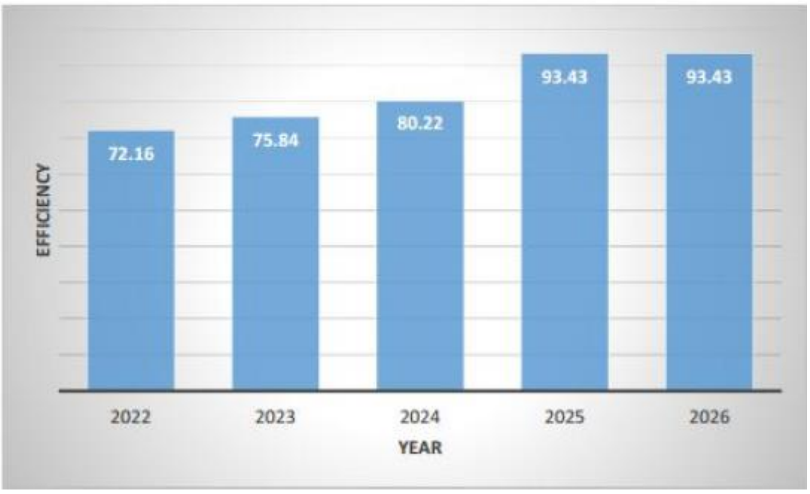

Figure 4.4: Efficiency prediction curve

The efficiency model (equation 4.28) was used to plot the efficiency curve in Figure 4.1 and the efficiency chart, Figure 4.2 and was also used for the prediction as illustrated in the Figure 4.4 It showed the gradual optimum values for the next five years to come based on the model of efficiency in power distribution in Ilorin.

V. CONCLUSION

This study investigated the efficiency level of power distribution in Ilorin using linear programming method of optimization technique. The result showed that IBEDC in Ilorin, despite receiving electric power that is not sufficient to serve the people of Ilorin effectively have not been functioning to their best based on the amount of power they are able to bill from the amount they are receiving currently. More so, the study also established that there is a significant loss of energy from the little available that can be distributed in order for the unit to function optimally for a better performance. The study was able to predict future efficiency levels for the next five years in the following order 72.16%, 75.84%, 80.22%, 93.43% and 93.43% using Mathlab and Maple for numerical computation of the efficiency model created by Newton Gregory Backward Difference Formula. From this research work, it can be concluded that despite the huge investments in the power sector since after independence, the country with over 180 million people has a recurring cycle with little or no development in the power sector. Particularly in Ilorin Metropolis the capital city of Kwara state, the research was able to establish that the IBEDC in Ilorin has been receiving voltage of electric power that is very small compare to the amount needed to serve the entire city effectively. Obviously, it is a public knowledge that there is a problem of low power generation from the national grid which directly influences the little available amount that is being transmitted and distributed to various states and to local government level. The energy sector can however be improved to function optimally if we reduce the amount of wasted energy on a monthly basis and make judicious use of the little being generated till the system becomes better.

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