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Electricity Distribution Efficiency Using Energy Meters and Quadratic Regression Model

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ABSTRACT: *Electricity distribution is a means of dispatching electrical energy to various customers connected to the distribution network. This study was comprehensive in energy forecasting in electricity distribution network using energy meters and quadratic regression model as it was geared towards the most efficient way of providing electricity for the numerous customers that are in dear need of electricity in Nigeria, especially Port Harcourt electricity distribution network. Relevant data such as Rumuolumeni feeder route length, feeder conductor size, feeder availability, feeder daily load, energy consumption on six smart energy metered households and on six analogue energy metered households respectively all connected to Rumuolumeni 33kV feeder, Rumuolumeni feeder customer population and population not connected to the network were collected from Port Harcourt Electricity Distribution Company (PHEDC). Data collected were analyzed to determine the average and maximum energy consumed in the years 2020 and 2021 and yet fed into excel software for statistical analysis. The regression model on smart meters provided forecast values of 12006.8542Kwh, 12350.5338Kwh, 12779.6825Kwh, 13294.426Kwh and 13931.039Kwh respectively for five years and 15832.3908Kwh, 16451.6191Kwh, 17225.0122Kwh,18152.56992Kwh and 19234.2922Kwh respectively on analogue meters for five years. Total energy forecast on smart meters for five years was 64362.5355Kwh while that of analogue meters was 86895.8842Kwh. Predicted energy consumption for the five years on analogue meters was greater than that of smart meters by 22533.3487Kwh representing 35.01% energy consumption increase. The energy margin shows that low energy consumption is more implemented using smart meter than analogue meter.*

KEYWORDS: *Energy efficiency, Energy forecasting, Quadratic regression model. Smart meter, Analogue meter.*

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I. INTRODUCTION

Electricity distribution efficiency refers to the distribution of electrical energy in the manner that would effectively cut down losses. By this, technical and non-technical losses are minimized. Energy efficiency refers to the utilization of less energy input to achieve the same level of services whereby electricity becomes more affordable and at the same time facilitating loss reduction of the energy providing company [1]. Losses always occur in transmission and distribution sections of the power system and they become difficult to account for due to huge disparity in several cases [2]. Non-technical losses include commercial and collection losses. Technical losses according to Mohsin et al.[3], are losses that arise due to resistance to the flow of current in materials and the resultant energy loss dissipated in the form of heat. These losses are sudden conversion from useful electricity to heat where heat is not needed.

According to Nwohu et al.[4], commercial losses refer to the disparity due to non-capturing of all billable electrical energies. That is to say, losses occur if energy reading is avoided or inaccurate readings are in place. Other problems that can lead to commercial losses are energy theft, use of inefficient meters, faulty and inefficient bills production, unresolved disputes and others. Collection losses are losses that arise due the inability of the power utility company to receive payments from her customers for energy consumed [4]. Nwohu et al. [4] further maintained that collection losses might result from inability to collect bill payment or distribute bills to the right customers. Adedamora[5] stated that Nigeria has high percentage of non-technical losses.

From the foregoing, it is imperative to make the distribution of electrical energy efficient using smart meter. This process if it is well planned and implemented, will minimize losses and over-billing for services rendered to customers.

II. RELATED WORKS

According to Igbogidi et al. [6], accurate method and models for electrical energy forecasting are very imperative for planning and operation of every utility company. Quadratic regression model is very efficient in predicting events ahead.

Tronget al.[7] maintained that smart meter has the property to identify electrical power utilization in much more explicit form than an analogue meter and periodically transmit the collected information back to the electrical energy provider for load monitoring and billing purposes. In the same vein, Almaralet al.[8] maintained that information received from smart meters serve the purpose of managing the customers and the distribution network. Smart meters have the ability to detect energy theft and generally possess high energy efficient properties.

Smart meters are generally built to record how much electrical energy is utilized and at what time [9]. The advent of smart meter is rapidly phasing away the conventional metering system which provides supports to localized, manual, and non-interactive data collection. The need for smart energy meters in power distribution industries is inevitable and that is why much has been done especially in the area of energy management choices in the home [10]. If the efficiency of the grids must be improved then smart grid is required because it communicates data in real time to customers and energy providers [11].

Full use of smart energy meters in electricity distribution network gives room to less utilization of energy even while performing the same task thereby freeing more energy to meet other demands [12]. In the same vein, Douglas,et al [13] maintained that without increasing carbon emission, energy efficiency can be increased by using smart energy meter in the distribution network.

III. MATERIALS AND METHOD

3.1 Research Materials

Data required for a comprehensive analysis and investigation of the study area which are twelve households were collected from the Port Harcourt Electricity Distribution Company (PHEDC). Feeder availability in hours per day was also collected for this research. The method and procedure adopted in this research are described accordingly.

3.2 Method of Analysis

The study was conducted on Port Harcourt electricity distribution network based on past and present energy consumptions. The energy forecasting was implemented on twelve households comprising of two-bedroom flats each at Rumuolumeni Town, where the first six households make use of smart meter while the other six have analogue meter all feeding from Rumuolumeni 33kV feeder which radiates from Port Harcourt Town 132/33kV Transmission Station. For purpose of clarity, the data were taken from Port Harcourt Electricity Distribution Company (PHEDC).

For the purpose of this research, the meters were tagged meter 1, meter 2, meter 3, meter 4, meter 5 and meter 6 (smart meters). Also tagged were meter 7, meter 8, meter 9, meter 10, meter 11 and meter 12 (analogue meters) respectively. After carefully analyzing the historical data between years 2020 and 2021, a quadratic regression model was employed. In this study, the quadratic regression model is a hybrid model that utilizes both time series and time trend modelling approach combined with regression analysis for a 5-year energy forecast dwelling on historical data between the years 2020 and 2021. Table 3.1 contains some of the important data related to energy forecasting in the determination of which meter is better in the enhancement of the electrical energy distribution efficiency.

Table 3.1: Relevant Data for Analysis

S/NO	HOUSEHOLD	HIGHEST MONTHLY CONSUMPTION IN KWH IN THE YEAR 2020	HIGHEST MONTHLY CONSUMPTION IN KWH IN THE YEAR 2021
1	Meter 1	1944	2040
2	Meter2	1860	2208
3	Meter3	2112	2256
4	Meter4	1728	1824
5	Meter 5	1680	1920
6	Meter 6	1848	2136

7	Meter 7	2376	2520
8	Meter 8	2640	3072
9	Meter 9	2016	2520
10	Meter 10	2544	2976
11	Meter 11	2520	3024
12	Meter 12	2232	2400

Source:PHEDC

3.3 Energy Forecasting Using Quadratic Regression Model

In load forecasting, peak load can be obtained as:

$$Peak\ load = \frac{Energy}{Load\ factor\ X\ Period\ of\ time} \quad (1)$$

If weather is inclusive, then:

$$Peak\ load = a + b\ Xbase\ energy + weather \quad (2)$$

Where

Base energy is the non-weather-sensitive portion of the load.

The regression model is a hybrid having a mix of time series and time trend linked with regression analysis. The model provides a non-linear relationship between the predicted values of maximum annual energy consumed, $P(j)$ of a given year, w_j in the equation:

$$P(j) = a_1 + a_2 w_j + a_3 w_j^2 \quad (3)$$

Where

$P(j)$= the maximum annual energy utilized predicted for a particular year ahead in Kilowatts

w_j = any particular year as desired where the energy utilized may be predicted with integral values of j = 1, 2, 3, - - - k, (k+1), (k+2), (k+3)… (k+n).

a_1 = a constant of the model representing the average network base energy.

Finally, a_2 and $a_3$are coefficients of change representing maximum annual electrical energy utilized.

The regression model, $P(j) = a_1 + a_2 w_j + a_3 w_j^2$ is generated by using a set of time series data of annual maximum load consumption for a given k number of consecutive years of annual maximum load consumption and thereafter harnessed by applying a statistical approach referred to as regression analysis which gives rise to:

$$a_1 k + a_2 \sum_{j=1}^{k} w_j + a_3 \sum_{j=1}^{k} w_j^2 = \sum_{j=1}^{k} p_j \quad (4)$$

$$a_1 \sum_{j=1}^{k} w_j + a_2 \sum_{j=1}^{k} w_j^2 + a_3 \sum_{j=1}^{k} w_j^3 = \sum_{j=1}^{k} w_j p_j \quad (5)$$

$$a_1 \sum_{j=1}^{k} w_j^2 + a_2 \sum_{j=1}^{k} w_j^3 + a_3 \sum_{j=1}^{k} w_j^4 = \sum_{j=1}^{k} w_j^2 p_j \quad (6)$$

The actual values ofa_1, a_2 and a_3 are obtained by analytically evaluating equations (4), (5) and (6) respectively.

Table 3.2: Energy Consumption in KWH on Smart Meters in the Years 2020 and 2021

SMART METERS	ENERGY CONSUMPTION IN KWH IN THE YEAR 2020	ENERGY CONSUMPTION IN KWH IN THE YEAR 2021
Meter 1	1944	2040
Meter 2	1860	2208
Meter 3	2112	2256
Meter 4	1728	1824
Meter 5	1680	1920
Meter 6	1848	2136

Table 3.3: Energy Consumption in KWH on Analogue Meters in the Years 2020 and 2021

SMART METERS	ENERGY CONSUMPTION IN KWH IN THE YEAR 2020	ENERGY CONSUMPTION IN KWH IN THE YEAR 2021
Meter 7	2376	2520
Meter 8	2640	3072
Meter 9	2016	2520
Meter 10	2544	2976
Meter 11	2520	3024
Meter 12	2232	2400

3.3.1 Energy Forecasting on Smart Meters Using Quadratic Regression Model

The regression model is a combination of time series and time trend mixed with regression analysis which provides a non-linear relationship between the forecast values of annual energy consumed on Smart Meters 1 to 6 where $P(j) = a_1 + a_2 w_j + a_3 w_j^2$.

Table 3.4: Energy Forecasting on Meter 1

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	$w_j p_j$	$w_j^2 p_j$
2020	1	1944	1	1	1	1944	1944
2021	2	2040	4	8	16	4080	8160
Total	3	3984	5	9	17	6024	10104

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:

$2_{a_1} + 3_{a_2} + 5_{a_3} = 3984$

$3_{a_1} + 5_{a_2} + 9_{a_3} = 6024$

$5_{a_1} + 9_{a_2} + 17_{a_3} = 10104$

Analytically:

$a_1 = 1969.1294, \ a_2 = 3.501168 \ and \ a_3 = 3.38824$

Substituting these values into equation (4), the result becomes:

$p_{(j)} = 1969.1294 + 3.501168 w_j + 3.38824 w_j^2$

where $P(j) = a_1 + a_2 w_j + a_3 w_j^2$.

Table 3.5: Energy Forecasting on Meter 2

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	$w_j p_j$	$w_j^2 p_j$
2020	1	1860	1	1	1	1860	1860
2021	2	2208	4	8	16	4416	8832
Total	3	4068	5	9	17	6276	10692

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:

$2_{a_1} + 3_{a_2} + 5_{a_3} = 4068$

$3_{a_1} + 5_{a_2} + 9_{a_3} = 6276$

$5_{a_1} + 9_{a_2} + 17_{a_3} = 10692$

Analytically:

$a_1 = 1951.094125, \ a_2 = 12.69177 \ and \ a_3 = 12.28235$

Substituting these values into equation (4), the result becomes:

$p_{(j)} = 1951.094125 + 12.69177 w_j + 12.28235 w_j^2$

Table 3.6: Energy Forecasting on Meter 3

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	$w_j p_j$	$w_j^2 p_j$
2020	1	2112	1	1	1	2112	2112
2021	2	2256	4	8	16	4512	9024
Total	3	4368	5	9	17	6624	11136

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:

$2_{a_1} + 3_{a_2} + 5_{a_3} = 4368$

$3_{a_1} + 5_{a_2} + 9_{a_3} = 6624$

$5_{a_1} + 9_{a_2} + 17_{a_3} = 11136$

Analytically:

$a_1 = 2149.6941, \ a_2 = 5.25177 \ and \ a_3 = 5.08235$

Substituting these values into equation (4), the result becomes:

$p_{(j)} = 2149.6941 + 5.25177 w_j + 5.08235 w_j^2$

where $P(j) = a_1 + a_2 w_j + a_3 w_j^2$.

Table 3.7: Energy Forecasting on Meter 4

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	1728	1	1	1	1728	1728
2021	2	1824	4	8	16	3648	7296
Total	3	3552	5	9	17	5376	9024

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 3552$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 5376$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 9024$
Analytically:
$a_1 = 1753.1294, \ a_2 = 3.50117 \ and \ a_3 = 3.38824$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 1753.1294 + 3.50117w_j + 3.38824w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

Table 3.8: Energy Forecasting on Meter 5

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	1680	1	1	1	1680	1680
2021	2	1920	4	8	16	3840	7680
Total	3	3600	5	9	17	5520	9360

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 3600$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 5520$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 9360$
Analytically:
$a_1 = 1742.8235, \ a_2 = 8.75294 \ and \ a_3 = 8.47059$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 1742.8235 + 8.75294w_j + 8.47059w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$

Table 3.9: Energy Forecasting on Meter 6

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	1848	1	1	1	1848	1848
2021	2	2136	4	8	16	4272	8544
Total	3	3984	5	9	17	6120	10392

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 3984$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 6120$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 10392$
Analytically:
$a_1 = 1923.3882, \ a_2 = 10.50352 \ and \ a_3 = 10.16471$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 1923.3882 + 10.50352w_j + 10.16471w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

3.3.2 Energy Forecasting on Analogue Meters Using Quadratic Regression Model

The regression model is a combination of time series and time trend mixed with regression analysis which provides a non-linear relationship between the forecast values of annual energy consumed on Analogue Meters 7 to 12 where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

Table 3.10: Energy Forecasting on Meter 7

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	2376	1	1	1	2376	2376
2021	2	2520	4	8	16	5040	10080
Total	3	4896	5	9	17	7416	12456

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 4896$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 7416$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 12456$
Analytically:
$a_1 = 2413.6941,\ a_2 = 5.25177\ and\ a_3 = 5.08235$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 2413.6941 + 5.25177w_j + 5.08235w_j^2$

Table 3.11: Energy Forecasting on Meter 8

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	2640	1	1	1	2640	2640
2021	2	3072	4	8	16	6144	12288
Total	3	5712	5	9	17	8784	14928

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 5712$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 8784$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 14928$
Analytically:
$a_1 = 2753.0824,\ a_2 = 15.7553\ and\ a_3 = 15.24706$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 2753.0824 + 15.7553w_j + 15.24706w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

Table 3.12: Energy Forecasting on Meter 9

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	2016	1	1	1	2016	2016
2021	2	2520	4	8	16	5040	10080
Total	3	4536	5	9	17	7056	12096

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 4536$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 7056$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 12096$
Analytically:
$a_1 = 2147.9294,\ a_2 = 18.38117\ and\ a_3 = 17.78824$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 2147.9294 + 18.38117w_j + 17.78824w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

Table 3.13: Energy Forecasting on Meter 10

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	2544	1	1	1	2544	2544
2021	2	2976	4	8	16	5952	11904

Total	3	5520	5	9	17	8496	14448

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 5520$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 8496$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 14448$
Analytically:
$a_1 = 2657.0824, \; a_2 = 15.75530 \; and \; a_3 = 15.24706$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 2657.0824 + 15.75530w_j + 15.24706w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

Table 3.14: Energy Forecasting on Meter 11

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	2520	1	1	1	2520	2520
2021	2	3024	4	8	16	6048	12096
Total	3	5544	5	9	17	8568	14616

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 5544$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 8568$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 14616$
Analytically:
$a_1 = 2651.9294, \; a_2 = 18.38117 \; and \; a_3 = 17.78824$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 2651.9294 + 18.38117w_j + 17.78824w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

Table 3.15: Energy Forecasting on Meter 12

YEAR	w_j	p_j	w_j^2	w_j^3	w_j^4	w_jp_j	$w_j^2p_j$
2020	1	2232	1	1	1	2232	2232
2021	2	2400	4	8	16	4800	9600
Total	3	4632	5	9	17	7032	11832

Equations (4), (5) and (6) respectively having been resolved using the results in the table become:
$2_{a_1} + 3_{a_2} + 5_{a_3} = 4632$
$3_{a_1} + 5_{a_2} + 9_{a_3} = 7032$
$5_{a_1} + 9_{a_2} + 17_{a_3} = 11832$
Analytically:
$a_1 = 2275.9765, \; a_2 = 6.12706 \; and \; a_3 = 5.92941$
Substituting these values into equation (4), the result becomes:
$p_{(j)} = 2275.9765 + 6.12706w_j + 5.92941w_j^2$
where $P(j) = a_1 + a_2w_j + a_3w_j^2$.

IV. RESULTS AND DISCUSSION

4.1 Analysis from Regression Result on Smart Energy Meters

The results obtained from the regression analysis being essentially the forecast values in KWH on smart meters 1, 2, 3, 4, 5, and 6 connected to Rumuolumeni 33kV feeder are shown in Table 4.1 and Figures 4.1, 4.2, 4.3, 4.4, 4.5, and 4.6 respectively.

Table 4.1: Energy Forecast in KWH on Smart Meters for 5-Years

YEAR	METER 1 ENERGY FORECAST IN KWH	METER 2 ENERGY FORECAST IN KWH	METER 3 ENERGY FORECAST IN KWH	METER 4 ENERGY FORECAST IN KWH	METER 5 ENERGY FORECAST IN KWH	METER 6 ENERGY FORECAST IN KWH
2022	2010.1271	2099.7106	2211.1906	1794.1271	1845.3176	2046.3812
2023	2037.3880	2198.3788	2252.0188	1821.3459	1913.3647	2128.0376
2024	2071.3412	2321.6117	2303.0117	1855.3413	1998.3530	2230.0236
2025	2112.1130	2469.4093	2364.1693	1896.1131	2100.2824	2352.3389
2026	2159.6613	2641.7717	2471.8080	1943.6614	2219.1530	2494.9836

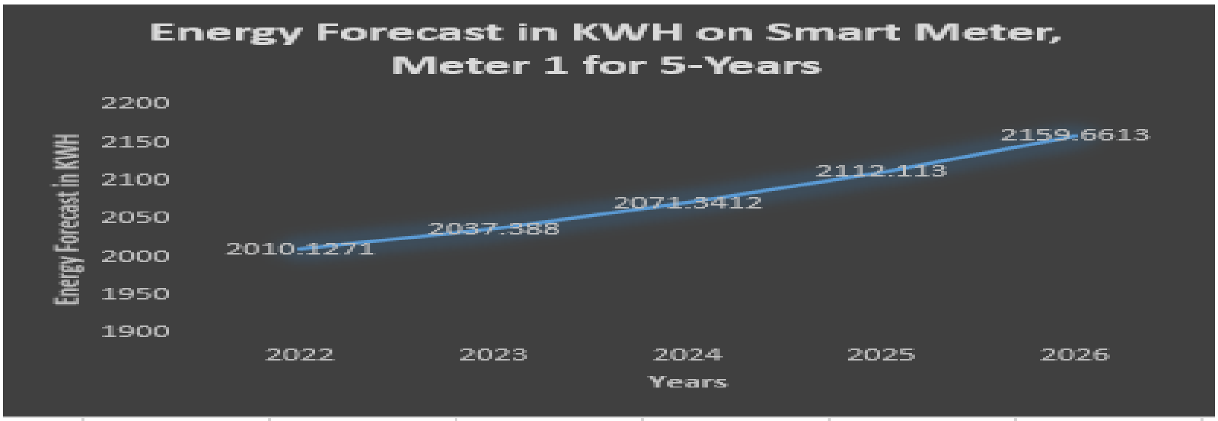

Figure 4.1: Graph Showing Energy Forecast in KWH on Smart Meter, Meter 1 for 5-Years

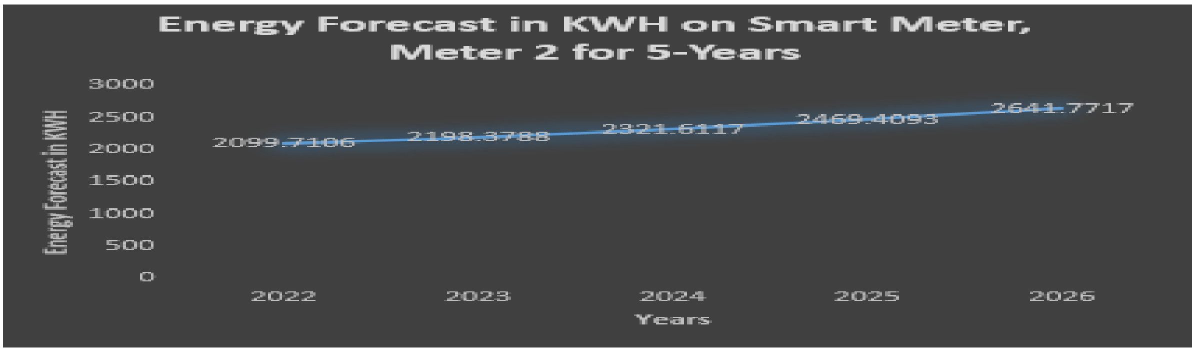

Figure 4.2: Graph Showing Energy Forecast in KWH on Smart Meter, Meter 2 for 5-Years

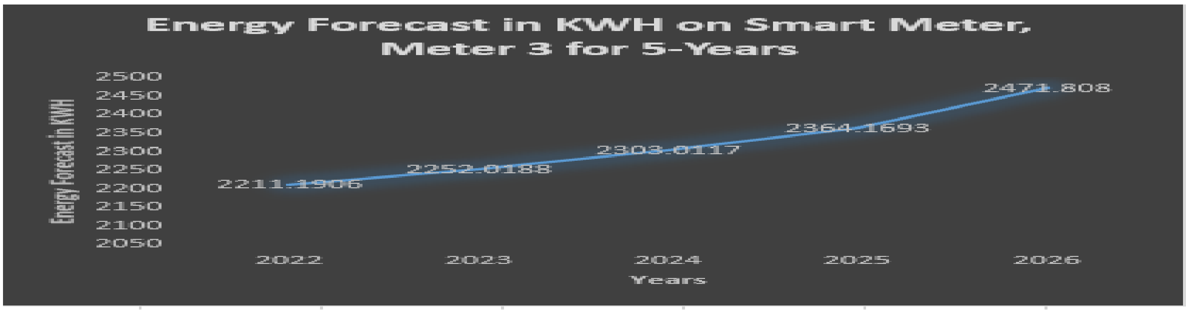

Figure 4.3: Graph Showing Energy Forecast in KWH on Smart Meter, Meter 3 for 5-Years

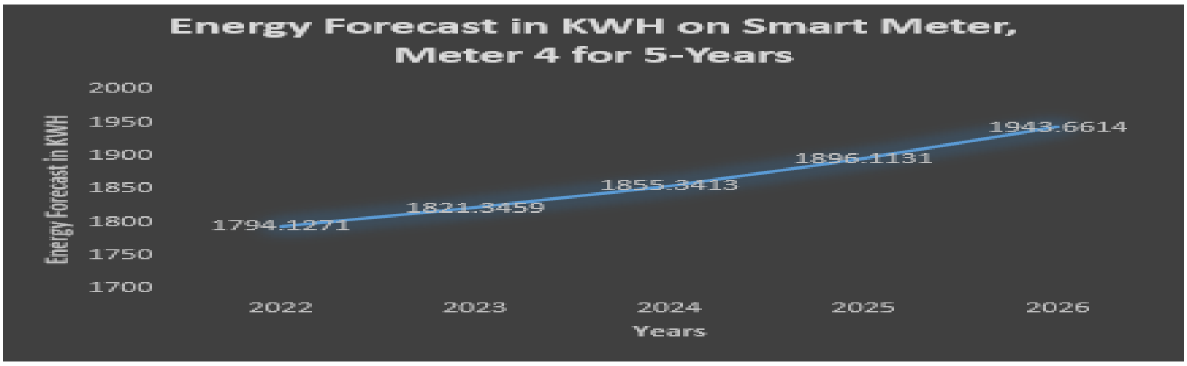

Figure 4.4: Graph Showing Energy Forecast in KWH on Smart Meter, Meter 4 for 5-Years

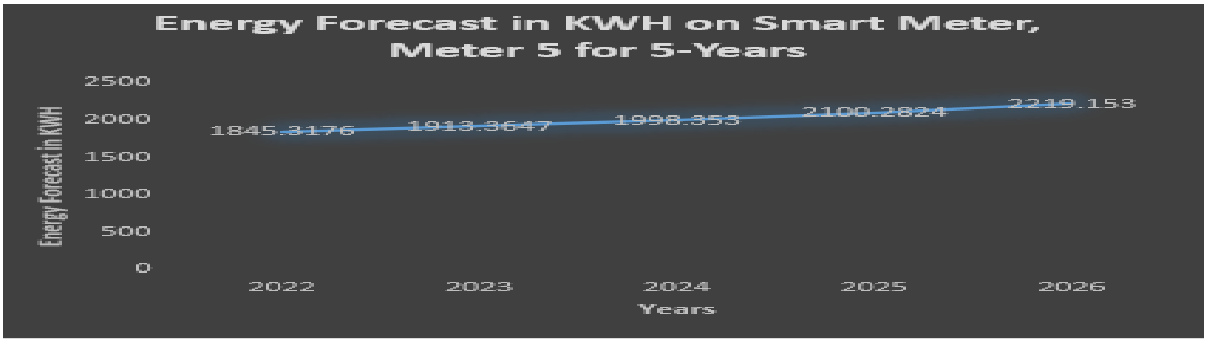

Figure 4.5: Graph Showing Energy Forecast in KWH on Smart Meter, Meter 5 for 5-Years

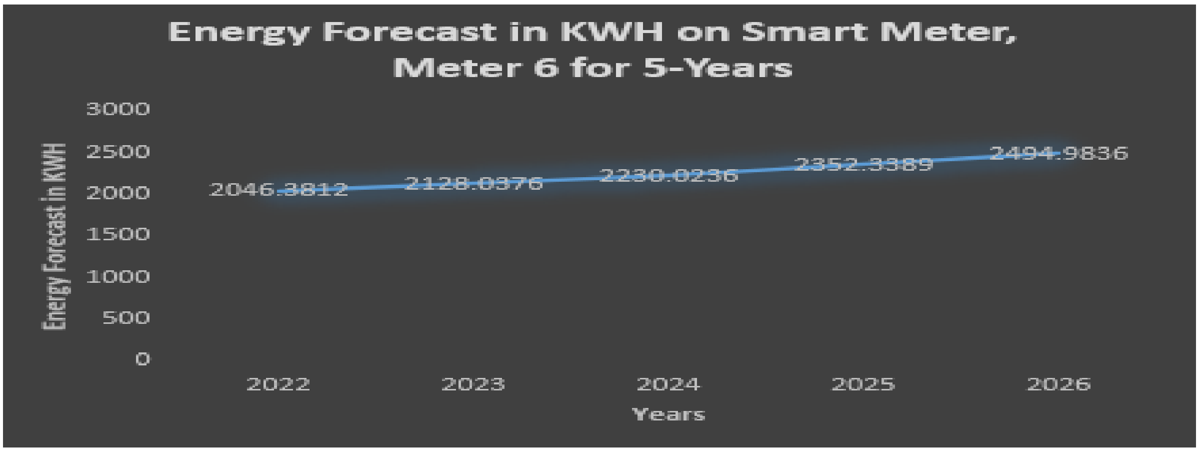

Figure 4.6: Graph Showing Energy Forecast in KWH on Smart Meter, Meter 6 for 5-Years

4.2 Analysis from Regression Result on Analogue Energy Meters

The results obtained from the regression analysis being essentially the forecast values in KWH on analogue meters F, G, H, I, and J connected to Airport 33kV feeder are shown in Table 4.2 and Figures 4.7, 4.8, 4.9, 4.10, 4.11, and 4.12 respectively.

Table 4.2: Energy Forecast in KWH on Analogue Meters for 5-Years

YEAR	METER 7 ENERGY FORECAST IN KWH	METER 8 ENERGY FORECAST IN KWH	METER 9 ENERGY FORECAST IN KWH	METER 10 ENERGY FORECAST IN KWH	METER 11 ENERGY FORECAST IN KWH	METER 12 ENERGY FORECAST IN KWH
2022	2475.1906	2937.5718	2363.1671	2841.5718	2867.1671	2347.7224
2023	2516.0188	3060.0566	2506.0659	2964.0566	3010.0659	2395.3553
2024	2567.0117	3213.0354	2684.5413	3117.0354	3188.5413	2454.8471
2025	2628.1693	3396.5084	2898.5931	3300.5084	3402.5931	2526.19762

2026	2699.4916	3610.4754	3148.2214	3514.4754	3652.2214	2609.4070

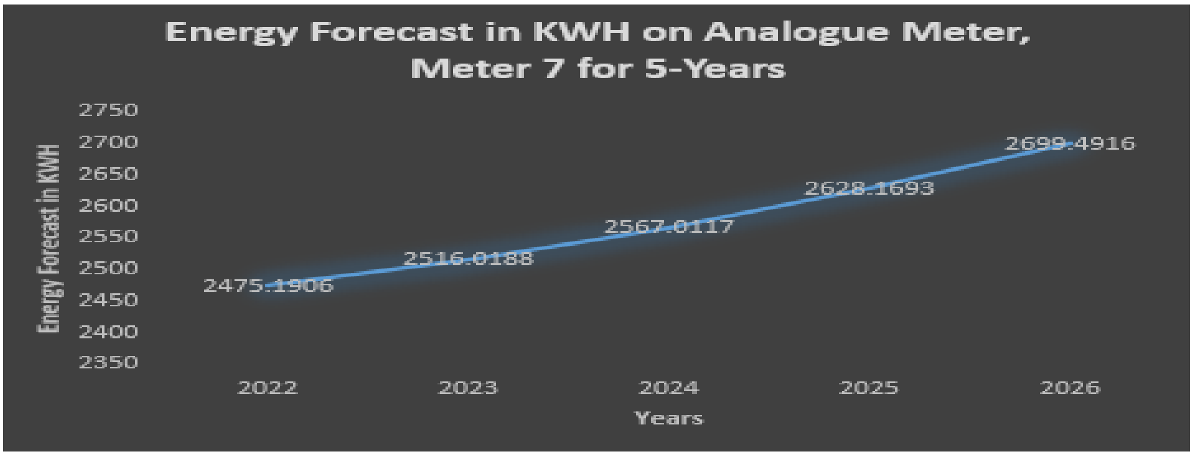

Figure 4.7: Graph Showing Energy Forecast in KWH on Analogue Meter, Meter 7 for 5-Years

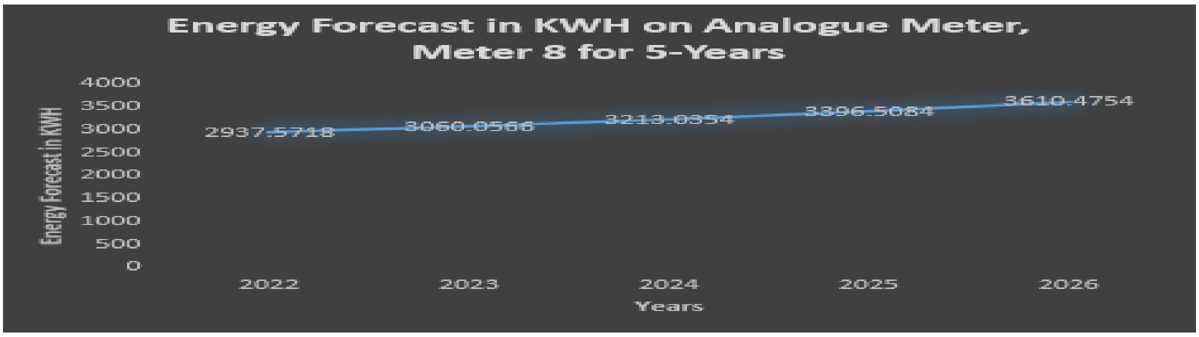

Figure 4.8: Graph Showing Energy Forecast in KWH on Analogue Meter, Meter 8 for 5-Years

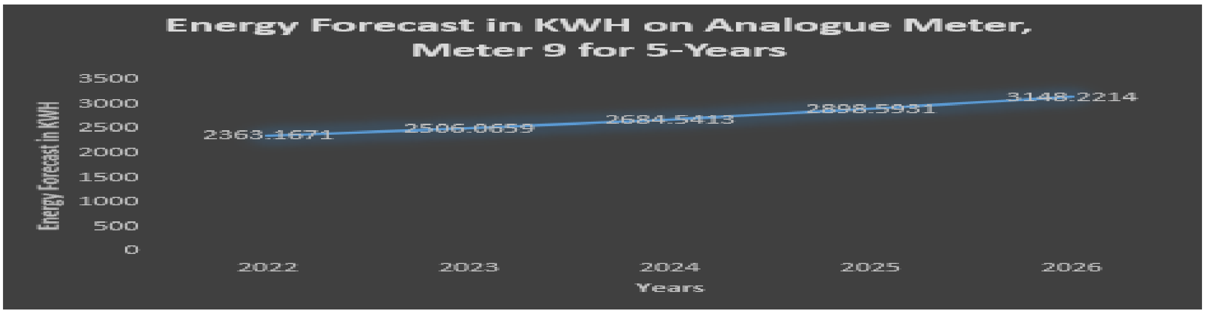

Figure 4.9: Graph Showing Energy Forecast in KWH on Analogue Meter, Meter 9 for 5-Years

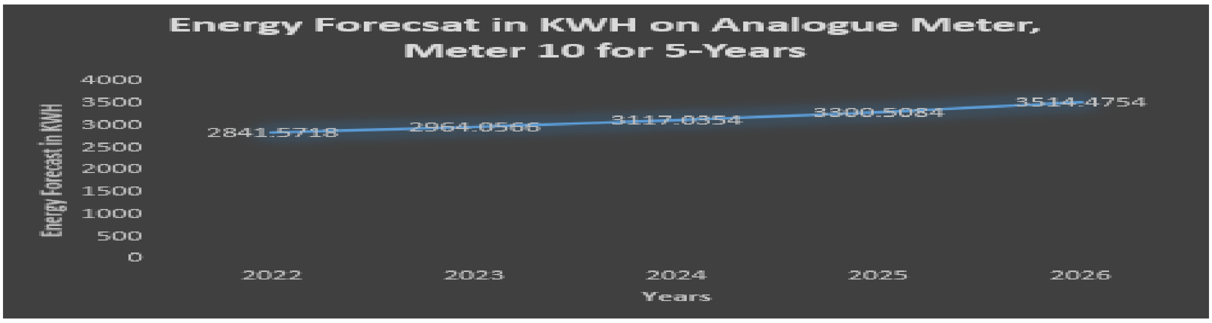

Figure 4.10: Graph Showing Energy Forecast in KWH on Analogue Meter, Meter 10 for 5-Years

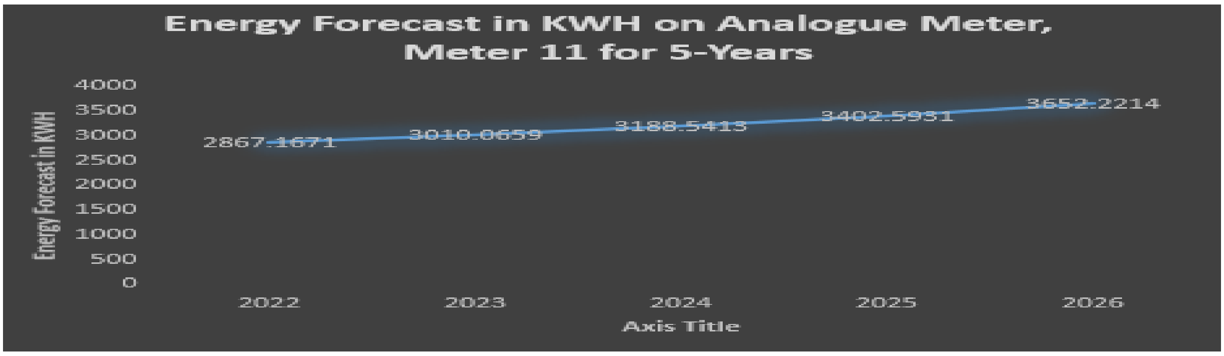

Figure 4.11: Graph Showing Energy Forecast in KWH on Analogue Meter, Meter 11 for 5-Years

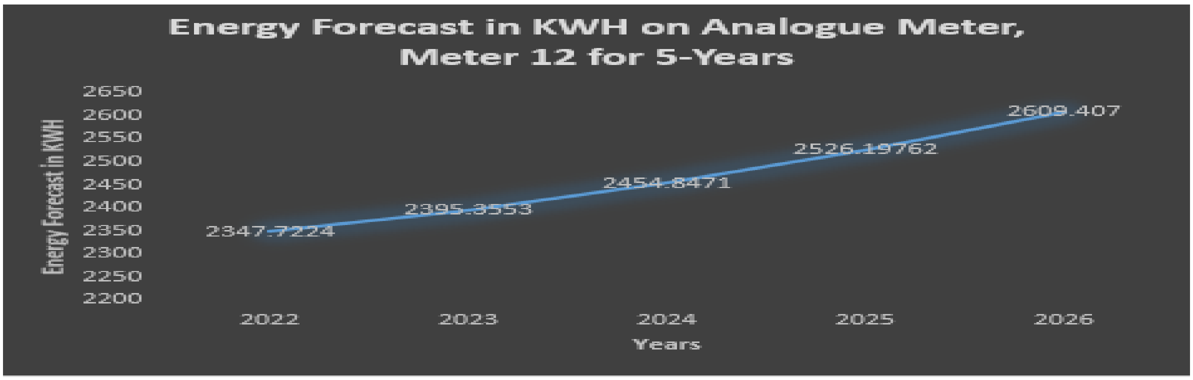

Figure 4.12: Graph Showing Energy Forecast in KWH on Analogue Meter, Meter 12 for 5-Years

4.3 Comparing Regression Results

Energy forecast values for 5-years on smart meters and analogue meters are compared in Table 4.3 and Figure 4.13 respectively.

Table 4.3 Comparing Energy Forecasts on Smart Meters and Analogue Meters

YEAR	ENERGY FORECAST SMART METER (KWH)	ENERGY FORECAST ANALOGUE METER (KWH)
2022	12006.8542	15832.3908
2023	12350.5338	16451.6191
2024	12779.6825	17225.0122
2025	13294.426	18152.56992
2026	13931.039	19234.2922

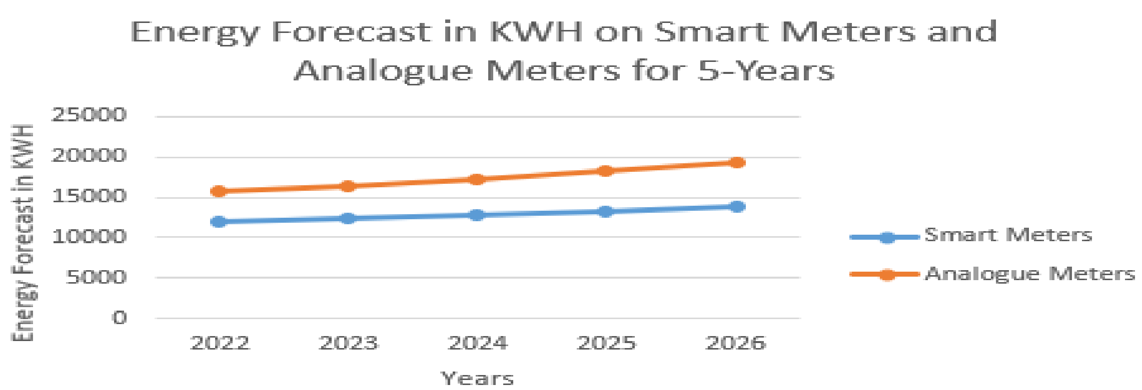

Figure 4.13: Graph Comparing Energy Forecast in KWH on Smart Meters and Analogue Meters for 5-Years

V. CONCLUSION

5.1 Conclusion

Data required for the energy forecast are majorly, 33kV line parameters, smart meters and analogue meters representing six households each at Rumuolumeni Town, Rivers State, Nigeria. Energy consumptions on the twelve households were considered. Energy consumption was classified based on the type of meter available in the study area. Monthly maximum energy consumptions in the years 2020 and 2021 for each of the twelve energy meters were taken and analyzed for five years ahead. The energy prediction was based on smart meters and analogue meters respectively on the principle of quadratic regression technique, as each group was six totaling twelve.

Quadratic Regression Model was used to forecast energy consumption on Smart Meters for five years which are 2022, 2023, 2024, 2025 and 2026 respectively. The energy forecast on smart meters for the five years became 12006.8542Kwh, 12350.5338Kwh, 12779.6825Kwh, 13294.426Kwh and 13931.039Kwh. Also based on the principles of quadratic regression model, the energy forecast on analogue meters for the five years became 15832.3908Kwh, 16451.6191Kwh, 17225.0122Kwh, 18152.56992Kwh and 19234.2922Kwh.

Comparatively, energy forecast on Smart meters for the five years is 64362.5355Kwh while that of analogue meters is 86895.8842Kwh. Predicted energy consumption for the five years on analogue meters is greater than that of smart meters by 22533.3487Kwh which represents 35.01% energy consumption increase. This energy margin signifies that low energy consumption is more implemented using smart meter than analogue meter as the user watches the billing process thereby giving room for power availability for others. The use of smart meters provides room for greater efficiency in energy distribution as compared to analogue meters. From the foregoing, energy growth rate can better be controlled using smart meters as the users generally control electricity usage thereby making its distribution efficient.

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