

Critical analysis of EEDC billing system in Enugu state

Oti Stephen Ejiofor^{1*}, Okoli Chinweike², Idoko Hillary³, Obe Titus⁴, Ihere Dennis⁵

¹⁻⁵ Department of Electrical Engineering, University of Nigeria, Nsukka, Enugu State, Nigeria

Abstract

In the analysis of Enugu Electricity Development Company (EEDC) billing system in Enugu State of Nigeria, a lot of measures were set aside to see that every concept applied by the EEDC was being considered. The distribution company adopted the base model of the utility billing software, (UBS plus @ electric) as regulated by the Nigeria Electricity Regulatory Commission (NERC) to generate the tariff charge for the different categories of consumers, comprising of the residential, industrial, commercial and special areas. These generated tariff charge for the different categories of consumers were analyzed with respect to how they affected electric bills and its past, present and future values were also evaluated. In the course of the research, it was depicted that the National generated capacity of power could affect the availability of electricity in the State. The "anti-theft module" and the "Revenue Collection System" are critical to the success of any Supply authority. Currently, pre-payment metering is quite cheaper to administer as it does not require the technical crew or operations of a conventional system. Pre-payment metering also has the added advantage because the consumer is in charge of his own usage and budgeting of electricity and as such should be fully implemented within the State to increase the efficiency of the existing billing system.

Keywords: tariff, energy meter, billing system, electricity, power, transmission, utilities

1. Introduction

The pre-payment system allows for electricity to be perceived for what it is, that is, a product that is purchased and consumed. As every distribution company would want to relieve itself of the burden of managing such a tedious system, pre-payment metering allows for the contracting or franchising out to private enterprise. This has an added merit that the distribution company can determine the true cost of management in advance and budget likewise. The concept of power billing is of utmost importance and cannot be over emphasized because its calculation reflects the exact power consumption for the prospective consumers, and in monitoring the billing details of the electricity consumers. It reduces the activities of those involved in energy theft ^[1, 3] as it cannot be easily eradicated. Such reduction will no doubt make electricity available to large scale and small scale enterprises ^[4]. It also provides an environment to maintain the consumer details starting from getting new connection, receiving bill, payments etc. ^[5]. The aim of this work is to critically analyze billing system in Enugu State through their various tariff charges as adopted by the Enugu Electricity Distribution Company (EEDC) and to ascertain the most economical energy meter to use. The justification of this write-up is to critically analyze the billing system by EEDC in Enugu State comparing the Modus Operandi they applied in the past, to that which is obtainable at the moment and application of new models to see to a positive transition that could be beneficial to both the consumers and the utilities and could probably be improved upon. Enugu Electricity Distribution Company (EEDC) comprises of fourteen (14) business units spread within the five states of South East geo-political region; Enugu, Imo, Abia, Anambra and Ebonyi State. The business units are: Aba, Abakaliki, Abakpa, Ariaria, Awka, Ekwulobia, Mbaise, Nnewi, Ogidi, Ogui, Onitsha, Orlu, Owerri and Umuahia. The Peak Demand of Enugu Electricity Distribution

Company is 1,017MW (including suppressed loads) with Enugu state having an estimated power of 130MW. The total 33/11KV Injection Substations is 103 (137 No. of Transformers) with installed capacity of 957.75MVA. The total number of distribution substations is 8,920 with a cumulative capacity of 2,591.95MVA. Total Route lengths of 33KV, 11KV and 0.415KV lines are 6596.4km, 3464.8km and 25,707.84km respectively ^[6]. Electrical meter or energy meter is a device that measures the amount of electric energy consumed by a factory, institution, residence, a business, or an electrically powered device. "Time of day" metering allows electric rates to be changed during a day, to record usage during peak high-cost periods and off-peak, lower-cost, periods. Also, in some areas meters have relays for demand response load shedding during peak load periods ^[7]. Additionally, there are single phase, three phase meters and another set of meter classified as maximum demand (M.D) meters. The single phase and three phases are single unit meters that indicate the consumers' consumption in kilowatt-hour (kWh) whereas the maximum demand meter is a set of two unit meters.

2. Material and Methods

2.1 The Mathematical Modelling

Analyzing the economics of cogeneration has been grouped into two models. The first model points that the demand for electricity, the electricity billing, the price of natural gas for the heating, a firms' ability to switch fuels, and plant output level measured by the total plant operating hours ^[8]. Mathematically, the model is given by:

$$E_P = \alpha_0 + \alpha_1 E_D + \alpha_2 + G_E + \alpha_3 G_P + \alpha_4 P_H + \alpha_5 F_S + U_1 \quad (1)$$

Where E_P = electricity billing charge in ₦/kWh
 E_D = electricity demand estimated
 G_E = generated electricity on site

G_P = gas or thermal energy price

P_H = plant hours

F_S = fuel switching ability (0, 1)

U_1 = model constraint (economical/social constrain price factors)

Electricity billing charge E_P for the various tariff codes is dependable on G_E , G_P and P_H as follows;

$$E_P (R2S) = 0.3 + 0.6(1) + 1.2 + 1 + 2.4(2) + 4.8(2.28) + 9.6(0.5) + 3.5 = \text{₦}27.14/\text{kWh} \quad (2)$$

$$\text{Generation cost} = G_E + \alpha_3 G_P + \alpha_4 P_H = 1 + 2.4(2) + 4.8(2.28) = \text{₦}16.74/\text{kWh} \quad (3)$$

$$E_P (C1T) = 0.3 + 0.6(1) + 1.2 + 2.5 + 2.4(4) + 4.8(2.95) + 9.6(0.5) + 3.5 = \text{₦}36.66/\text{kWh} \quad (4)$$

$$\text{Generation cost} = G_E + \alpha_3 G_P + \alpha_4 P_H = 2.5 + 2.4(4) + 4.8(2.95) = \text{₦}26.26/\text{kWh} \quad (5)$$

$$E_P (L1) = 0.3 + 0.6(1) + 1.2 + 1.5 + 2.4(3) + 4.8(2.45) + 9.6(0.5) + 3.5 = \text{₦}30.86/\text{kWh} \quad (6)$$

$$\text{Generation cost} = G_E + \alpha_3 G_P + \alpha_4 P_H = 1.5 + 2.4(3) + 4.8(2.45) = \text{₦}20.46/\text{kWh} \quad (7)$$

The calculated results are presented in table 1 and the tariff code is characterized in table 2.

Table 1: Base Model Classification {NERC}

Tariff codes	Electricity price ₦/ kWh	Distribution loss (α)	Generation cost ₦/ kWh	Service cost ₦/ kWh
R2S	27.14	30%	16.744	10.40
C1T	36.66	30%	26.26	10.40
L1	30.86	30%	20.46	10.40

Table 2: Tariff Code Classification {NERC}

Category	Old class	New class	Sources of supply	Remarks
Residential	R1	R1	Single phase supply with single phase meter with consumption below 50kWh.	A customer who uses his premises exclusively as a residence (house, flat, or multi-storey house.)
	R2	R2S	Single phase supply with single phase meter with consumption above 50kWh	
		R2T	Three phase supply with three phase meter.	
	R3	R3	Three phase supply with three phase meter with demand below 500kVA; LV Maximum demand.	
Commercial	C1	C1S	Single phase commercial supply with single phase meter.	A consumer who uses his premises for any purpose other than exclusively as a residence or as a factory for manufacturing goods.
		C1T	Three phase commercial supply with three phase meter.	
	C2	C2	Three phase commercial supply with three phase meter with demand less than 500kVA; HV maximum demand.	
	C3	C3	Three phase commercial supply on 6.6/11kV and/or 66/33kV with demand above 500kVA; HV maximum demand.	
Industrial	D1	D1S	Single phase industrial supply with single phase meter.	A consumer who uses his premises for manufacturing goods including welding and ironmongery.
		D1T	Three phase industrial supply with three phase meter.	
	D2	D2	Three phase industrial supply with three phase meter with demand less than 500kVA; LV maximum demand.	
	D3	D3	Large three phase industrial supply on 6.6/11kV and/or 66/33kV with demand above 500kVA; HV maximum demand.	
Street Lights	L1	L1	Large three phase industrial supply with three phase variable energy meter.	Used only in the night.
			Street lights.	
Special Areas	A1	A1S	Religious houses, agro-allied enterprises involving crop cultivation and/or livestock farming with single phase supply.	Customers such as agriculture and agro-allied industries, water boards, religious houses, government and teaching hospitals, government research institutes and educational establishments.
		A1T	Religious houses, agro-allied enterprises involving crop cultivation and/or livestock farming with three phase supply.	
	A2	A2	Universities, Government hospital etc. with demand less than 500kVA; LV maximum demand.	
	A3	A3	Universities, Government hospitals etc. on 6.6/11kV and/or 66/33kV with demand less than 500kVA; HV maximum demand.	

2.2 Determination of the Monthly bill

The Total bill per month (₦), (T_P) = ($E_P kWh + F + C$) + [$(E_P kWh + F + C)$] R + Z (8)

Where: E_P = Electricity billing charge in ₦/ kWh

kWh = total units consumed * m

F = Fixed charge per month in ₦

C = Meter maintenance charge per month in ₦

m = multiplier (adopted as 1.00 as stipulated by NERC).

($E_P kWh + F + C$) = energy sum in ₦/ kWh

R = VAT rate = 5% of energy sum Z = total arrears.

Assume, Previous reading = 70948 Present reading = 71448

kWh = Present reading – previous reading (9)

71448 - 70948 = 500 * m = 500 * 1 = 500 kWh (10)

Bill preparation of a residential area under the R2S tariff code in 2018:

$$(R2S) T_p = (E_p kWh + F + C) + [(E_p kWh + F + C)] R + Z \quad (11)$$

kWh= 500 $E_p = \text{₹}16.44/\text{kWh}$ $F=650$ $C=0$
 $Z=25,514.83$ $R=5\%=0.05$

$$(R2S) T_p = (16.44 * 500) + 650 + 0 + \{(16.44 * 500) + 650 + 0\} * 0.05 + 25,514.83 \quad (12)$$

$$(R2S) T_p = (8870) + (443.5) + (25,514.83) = \text{₹}34,828.33 \quad (13)$$

Bill preparation of the same residential area after fixed price removal and hike in tariff charge:

$$(R2S) T_p = (E_p kWh + F + C) + [(E_p kWh + F + C)] R + Z \quad (14)$$

kWh=500 $E_p = \text{₹}27.13/\text{kWh}$ $F=0$ $C=0$ $Z=25,514.83$
 $R=5\%=0.05$ $(R2S) T_p = (27.13 * 500) + 0 + 0 + \{(27.13 * 500) + 0 + 0\} * 0.05 + 25,514.83 \quad (15)$

$$(R2S) T_p = (13,565) + (678.25) + 25,514.83 = \text{₹}39,758.08 \quad (20)$$

Table 3: Implementation of Tariff (2018)

Implementation of New Tariff (2018)									
Tariff codes.	Energy charge per kWh (₹).	Assume total unit consumed	Energy sum consumed per month (₹).	Fixed charge per month (₹).	Meter maintenance per month (₹).	Minimum energy charge per month (₹).	VAT of 5%	Total arrears	Total bill per month (₹).
Residential									
R1	4.00	100	400	0	0	400	20	0	420.00
R2S	27.13	100	2713	0	0	2713	135.65	0	2848.65
R2T	27.13	100	2713	0	0	2713	135.65	0	2848.65
R3	45.10	100	4510	0	0	4510	225.5	0	4735.50
R4	43.19	100	4319	0	0	4319	215.95	0	4534.95
Commercial									
C1S	32.13	100	3213	0	0	3213	160.65	0	3373.65
C1T	36.78	100	3678	0	0	3678	183.9	0	3861.90
C2	42.40	100	4240	0	0	4240	212	0	4452.00
C3	42.97	100	4297	0	0	4297	214.85	0	4511.85
Industrial									
D1S	37.83	100	3783	0	0	3783	189.15	0	3972.15
D1T	38.68	100	3868	0	0	3868	193.4	0	4061.40
D2	42.80	100	4280	0	0	4280	214	0	4494.00
D3	43.89	100	4389	0	0	4389	219.45	0	4608.45
D4	30.79	100	3079	0	0	3079	153.95	0	3232.95
Street light									
L1	30.79	100	3079	0	0	3079	153.95	0	3232.95
Special tariff									
A1S	32.01	100	3201	0	0	3201	160.05	0	3361.05
A1T	36.78	100	3678	0	0	3678	183.9	0	3861.90
A2	42.41	100	4241	0	0	4241	212.05	0	4453.05
A3	42.23	100	4223	0	0	4223	211.15	0	4434.15

Consumers are classified based on their mode of consumption and by tariff classification. Usually electricity tariff are fixed by Government. Table 3 shows a representation of an estimated bill for the various tariff codes in the year 2018 with a uniform consumption rate of 100 units where fixed charges were removed and a 45% hike in tariff plan was introduced.

3.0 Analysis of Results

From the above table, it was deduced that the total electric bill still increased as compared to the past where there was

fixed charges. This change is independent of the constant consumption rate and fixed charge removal for the different tariff classes because of the hike in tariff charge.

The Federal Government reviewed the billing system in 2011 and due to cost in generation, it was further reviewed in 2015 and increased by 45% whose implementation commenced on February 01, 2016. From the decrease of Power Nationally, tariff charge is still going to be increased by 27% as speculated by NERC till 2018 then it starts depreciating at a percentage of 40% till 2024. The bar charts below depict the effects of tariff change on electricity bill amongst residential areas in Enugu State:

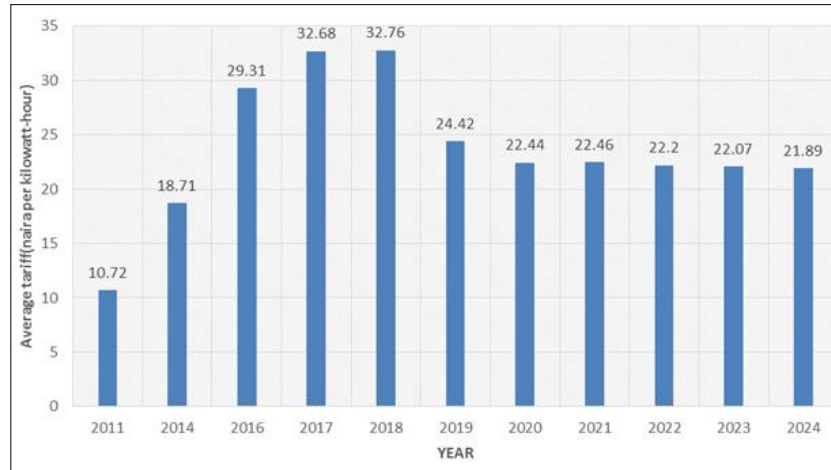


Fig 1: Graph of Average Residential Tariff per year.

The bar chart applies to other categories of consumers since the rate of increment up to 2019 and corresponding decrement to 2024 applied in all cases. This rate of change in tariff also had an impact on generated electricity bills since they are directly proportional.

Due to the constant complain of customers about the disadvantages associated with estimated billing system and the unreliable nature of the analog energy meter, strategies are being put into place to ensure that the electronic (pre-paid) energy meter gets to virtually every home in the rural and urban areas. How far and fast the pre-paid meters get to the customers is another unanswered question as the Distribution Companies (DisCos) are reported to be suffering close to ₦30 billion monthly owing to fixed pricing and electricity theft [2, 9] which is taken to constitute over 80% of the energy losses in Nigeria [10]. For Nigeria to take its rightful place in the committee of nations, its electricity poor availability which is compounded by the nonchalant attitude of 'those in power' must be dealt with.

4. Conclusion

Currently, in Enugu State, electronic (pre-paid) meters are being installed in newly built houses to reduce the demerits associated with estimated billing and the use of electromechanical energy meter. This is because every consumer wants to have a clear picture of the binding relationship between energy consumed and the exact amount he is to pay. This is to say that the advancement in technology, quest to eradicate the demerits associated with analog energy meters and the increase in the populace led to the computerization of billing operations in Enugu zone which is well appreciated by electricity users in the State. Some fraudulent acts like, meter reading dials to stop working while there is power in the meter and other abnormal events could be monitored through the application of the anti-theft module concept which would trigger the alarm in the master control room if the consumer engages in any illegal act. This module also informs the utility on consumers who have not cleared their debts, hence, could enhance automated disconnection of supply from the control panel without having any direct contact with the consumer. The Advanced Metering Infrastructure (AMI) implementation such as introduction of smart meters and

variable meters plays a large role in today's new strategies to meet the challenges of inefficiencies in estimated billing. AMI is an emerging technology growing from automated meter reading (AMR) of which the main goal of AMR was to reduce the costs of reading electrical meters, but AMI provides the capabilities based on bidirectional communications where data can be sent to a meter and/or customer as well as retrieved from it and, in some cases, the ability to execute control actions (such as shutting off electricity).

The future of electricity billing to the small power and commercial user lies in pre-payment metering especially in rural and third world communities. The reason for this is that pre-payment offers the user of electricity complete control over their consumption and convenience in payment as a benefit of implementation of Information Technology.

References

1. Smith TB. "Electricity theft: a comparative analysis," *Energy Policy*. 2004; 32(18):2067-2076. [https://doi.org/10.1016/S0301-4215\(03\)00182-4](https://doi.org/10.1016/S0301-4215(03)00182-4).
2. Shokoya NO, Raji AK. Electricity theft mitigation in the Nigerian power sector, *International Journal of Engineering & Technology*. 2019; 8(4):467-472. DOI: 10.14419/ijet.v8i4.29391.
3. Jiang R, Tagaris H, Lachsz A, Jeffrey M. "Wavelet based feature extraction and multiple classifiers for electricity fraud detection," in *Transmission and Distribution Conference and Exhibition*. 2002; 3:2251-2256.
4. Akuru UB, Okoro OI. "Economic implications of constant power outages on SMEs in Nigeria," *J. Energy South Africa*. 2014; 25(3):47-61. <https://doi.org/10.17159/2413-3051/2014/v25i3a2658>.
5. Seshanna NIP. "Automated Industrial Load Measurement System," *AU. J T*. 2006; 10(1):8.
6. Yahaya S. "Status of Technical and Commercial activities; Challenges and the way forward.," *Enugu Electricity Distribution Company*, 2012.
7. Edison. electric institute- *The Bible of electricity meters.*, "Minnkota Power's load management system", 2009.
8. Rathnayaka MR, Manamendra MA. "Mobile based

- electricity billing system (MOBEBIS)", International journal of scientific and research publications. 2013; 3(4).
9. "DisCos Lose. N30 Billion Monthly to Energy Theft, Others | Nigeria Electricity Hub, 2018. Available [Online]: <https://www.nigeriaelectricityhub.com/2018/06/08/disc-os-lose-n30-billion-monthly-to-energy-theft-others/>. [Accessed: 24-Oct-2019].
 10. Fidelis C, Chukwuemeka J, Onyinye AH. Controlling Electricity Theft, A Smart Meter Approach: Case Study of Nigeria, 2017.