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ELECTRIC BILL PAYMENTS BY UNMETERED CONSUMERS

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SUMMARY

Many electric energy consumers' premises are not metered. Accordingly estimated bills are sent to them. In some cases, meters are not read, but bills are still sent to consumers. This study showed that the estimated bills by **PHCN** sent to consumers, without meters is on the high side. It is very necessary for consumers to be billed for the actual energy consumed. That **PHCN** should ensure that all consumer premises are metered and accordingly when meters are not available **PHCN** should examine our work and do their own study and come to accurate figures for billing consumers.

INTRODUCTION

Energy in one form or the other is fundamental to all life and living worldwide; and indeed through out the Mighty Universe and every people must come to knowingly recognise this truth of life and living. Hence, wood and charcoal remain as very basic renewable energy sources before petroleum, gas, coal and today, electricity as a by product of primary energy sources which dominates every city, town and indeed every village dominated today's civilisation. Electricity is now the finest energy source man, discovered, and perhaps second to the solar radiation energy from the sun. Electric power is produced by a mechanical engine powered by a primary energy source rotating a conductor housed in slots in steel laminations in a magnetic field, which is also produced by the field winding of the generator rotor according to the equation,

$E = 2.22 f Ø_m Z K_w 1$ .... (1)

Where; f = frequency of the supply,

$Ø_m$ = the magnetic flux (webers) produced by the field winding of the generator's rotor-winding.

Z = no. of conductors connected in series usually in the stator,

K_{wl} = the fundamental winding factor.

The Power output from a given 3 – phase generator is then;

$P = \sqrt{3}\ V1t\cos\theta \times 10^{-3}$ Kw ....(2)Figure

1(a) shows a general representation of a generating system, and R Y : B a more detailed system is shown in figure (1b)

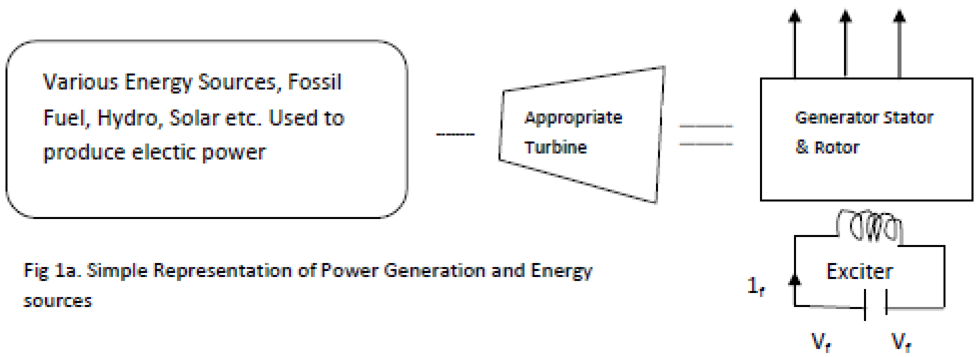

Fig 1a. Simple Representation of Power Generation and Energy sources

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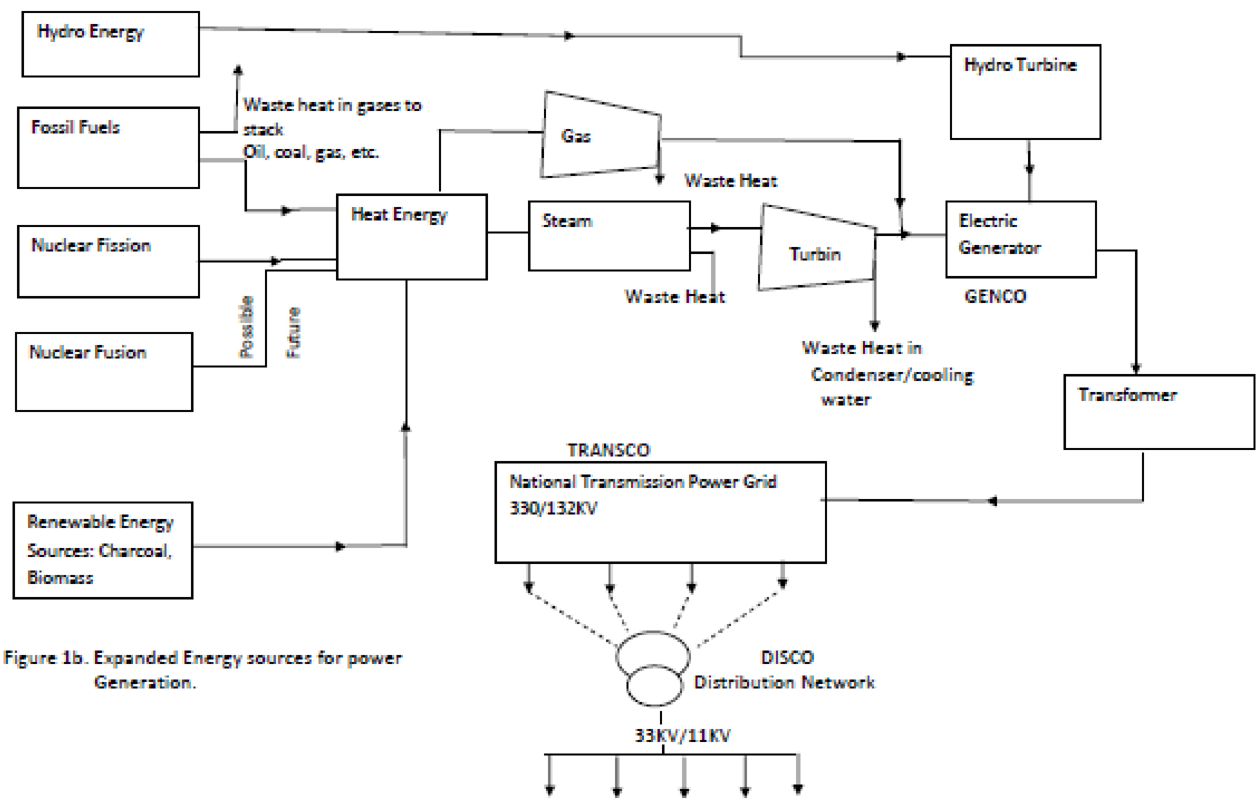


Figure 1b. Expanded Energy sources for power Generation.

Electric energy consumed is measured over the time duration the electric power is available, so that the corresponding equation is

Energy= $\int_{t1}^{t2} power\ dt$ ....(3)

Usually, the current varies with time but the (load) voltage can be assumed to be satisfactorily constant. However, we can write equation (3) as

Energy Produced or consumed = $\int_{t1}^{tn} (\Sigma V_i\, i i_1) \cos\theta_i\, dt$............(4)

Equation (4) can be examined numerically but in practice, the root mean square values are used.

Electric Energy Consumption

The effective electric energy production, transmission, distribution and utilisation/ consumption may be written in the form.

$E = \sqrt{3}$ V1t cos θ x 10^{-3} Kw4 .... (5)

Where **t** = time in hours power is used.

Devices which consume energy are many; motors, fridges, air-conditioners lamps, heaters, television sets and many more, which cannot be listed. All these are normally taken for granted, but it is a part-story of man's technological achievement7 as man progresses in time.

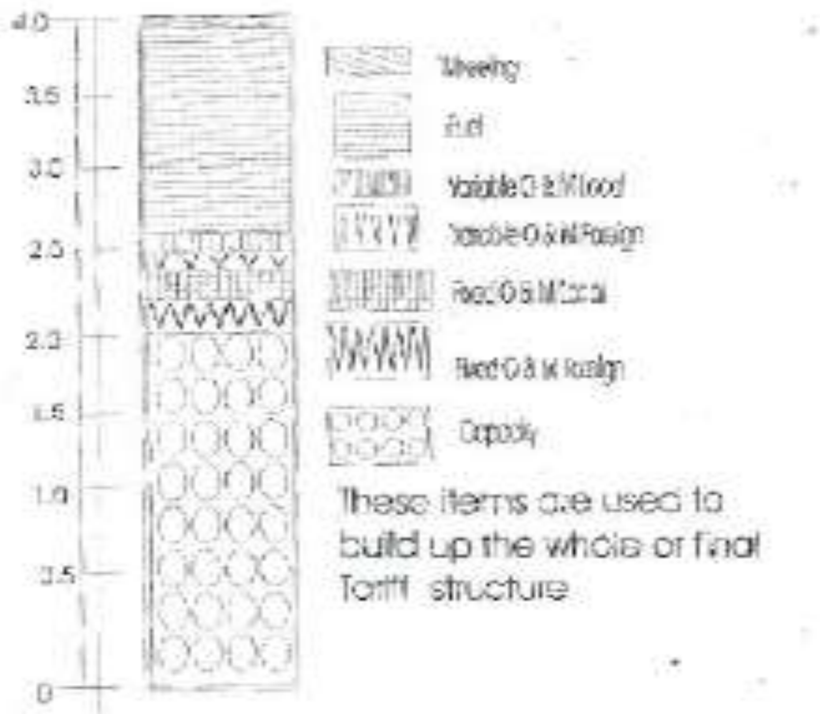
Energy Measurement and Pricing

It costs money to produce power or electric energy; and its production and consumption is perhaps the biggest machinery and system man has ever invented and put to use. The networks of power generation, transmission, distribution and utilization systems(2) (fig. 1b.) are well known to all who think. Even self propelling systems: – ships, trains, aircrafts, cars and space crafts and satellites, power generation, distribution and utilisation, generate their own power for one reason or the other. For the purpose of this work, we shall concern ourselves with energy metering systems and methods. In this, we consider, the watthour meters, pay as you use meters and approximate methods which need not be, but somehow such do exist throughout the country, and possibly in many developing countries[3]. The study is on the non-metered premises, but yet such premises/consumers are billed. The price of electricity (3,4,5) depends on; investment cost, interests on investment, fuel cost, operation and maintenance (**O & M**) cost, taxes paid, land use costs and amortization, figure 3. The country's power generation systems are slowly moving in the direction of Independent power plant (**IPP**) Projects and generated power is sold to would be independent marketers[5] or power distributors, and then to consumers. Between the power distributors and power generation are the power transmission groups popularly called Transco (transmission companies). (5) These new concepts are already being practised in many countries[(5)], basing electricity pricing on Power Purchase Agreement **(PPA**) document (4) to be signed between the power producer / owner, and the supply authority / power distributors. Power generation is a very expensive economic activity. All concerned must know for sure that energy availability is the main driver of a nation's economic activity, as well as the main power availability to lubricate the driven wheels of economy. Consider that the power purchase agreement (**PPA**), will of necessity mean that the power purchaser will take or pay for the energy generated; just as well, generating company has an obligation to generate and deliver power at a Minimum Energy Quantity (**MEQ**)[4], of net electrical output which the power distribution company must also take or pay for. The **MEQ** must be equivalent to the net power output that would be generated by the plant at an annual capacity factor of at least 85% if indeed the generating company has to stay in business and be competitive.

Tariff Concept

Electricity tariffs (3) are set up to recover all costs investments in the electricity production, distribution and even transmission, in the electricity supply industry world wide. This used to be the pyramid system of power supply. Figure 3 shows a typical ex-plant tariff components. The tariff takes full account of all the cost components of power generation leading to forming a satisfactory tariff, which must also include transmission, distribution and utilization costs.

Fig: 3 EX-PLANT TARIFF BREAKDOWN Tariff



An agreement will be reached as to how agreeable the tariff structure and its components will satisfy the power sellers' and buyers' aspirations. However, the ex-plant's tariff must cover all cost components for power production/generation, as well as the buyer's ability to purchase power, sell and make profit. In the case of the electricity buyer, there is another buyers tariff so as to profitably market the electric energy purchased from **GENCOS (power generating companies).** In some cases which affect total development, Government's subsidy may become necessary as this "new concept" is being further developed; for it will naturally take time to mature. From what has been said above, all the power generated in each of the generating stations in the country is easily sold to power distributors and marketers; (electricity buyers) but there is not enough power to serve the nation's power demand, at very low diversity factor, df . Ideally, df should be unity.

Metering of Electric Energy

Figures 4 show some types of energy meters in use; watt hour meters, three – phase and single phase types. In each of the types of meters, the voltage and current, values are so arranged in quadrature, so that meters' discs rotate, and so count the energy consumed which then is billed according to the prevailing tariffs. The situation is the same for pre-paid energy consumption fig. 4(b). Here, the consumer purchases the energy quantity he wants in advance. The disc rotates, totalling the energy being consumed, subtracting it from the original purchased value and continue/subtracting until the whole purchased energy is exhausted; in which case the consumer buys energy again, similar to the GSM phone practice. Figure 4c show energy consumption of two companies. Both consume the same energy quantity but the demands variations are different.

Other meter categories[10] are;

(a) Whole current (50A, Maximum Demand (MD))

(b) L.V.C.T. Operated MD (50 – 800 A)

(c) HV (C.T./V.T) operated MD (current is above 800 Amps). The first categories apply to residential and commercial consumers, while the 4th & 5th ((a) d c) apply mainly to industrial bulk energy consumers.

Figure 4a: Combined energy and demand meter

Fig.4b: Printing demand meter (General Electric) easily used For pay as you consume power. (i)

Add
(a) Hour meters
(b) Clip-on-meter (ii)

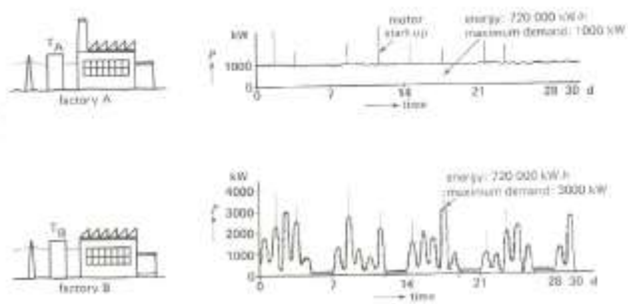


Figure 4c Comparison between two factories consuming the same energy but having different maximum demands.

New system in Electricity Marketing and Related Tariff

When power or energy is purchased from a generating Company, the energy buyer with his own tariff has to sell it so as to make some profit. Marketing Operation in Electric Power Systems[5] is now a very sophisticated field of study expanding into forecasting, scheduling, risk management and, even load shedding. There are very many complicated mathematical equations and formulations,[8] and related papers are in many published works.5 Electric energy marketing has lead to the restructuring of electricity supply from the traditional vertically integrated utility system, to creating new entities that can function independently. There is then a set up of an independent system operator and marketing (ISO) that coordinates all power generation and transmission; with power distribution and marketing in the electricity supply industry before the consumers' terminals. The **ISO** is the leading entity in the power market[5] operations and its function determines market rules. The key market entities are usually,

(a) GENCOS – Power generating Companies

(b) TRANSCOS – Power transmitting Companies

(c) DISCOS – Power distribution Companies and
(d) RETAILCOS – which includes the aggregators, brokers, marketers and customers. The latters are very often taken for granted in our present system.
But we should swing in the direction to which technology is ever again advancing.
Figure 5 shows the representation of **GENCO/TRANSCO** diagrammatic connection: Re-**Generation/Transmission** Interconnection system – a typical grid.

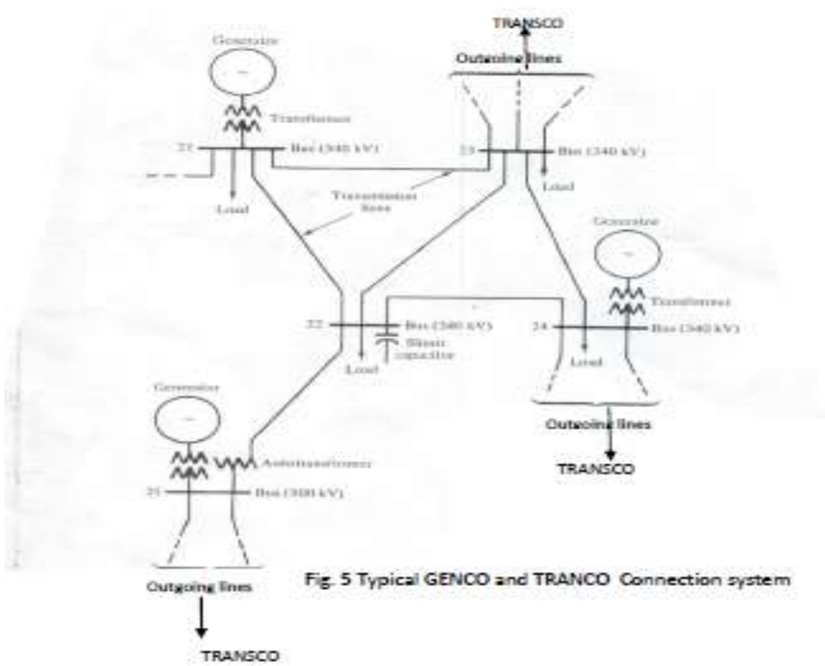


Fig. 5 Typical GENCO and TRANCO Connection system

The energy equation usually used in metering (5), may be re-written as,

$\boldsymbol{Eec} \int \boldsymbol{Pdt} = \sqrt{\boldsymbol{3}}\boldsymbol{V_L} \int \boldsymbol{i_i} \cos\theta \, dt$.................... (6) for three – phase supply system.

If metering is not possible, the supply company usually estimate es the energy consumed by using a diversity factor, d_f, so that for every month of 30 days, the current value average is taken as $Ia = \sum_1^{30} i/30$. The energy equation per month of 30 days and 24 hours/day becomes.

$Eec = \sqrt{3}V_L \sum_1^{30} i_t \cos\theta \times 30 \times 24 d_f$ .... (7)

Eec = 720 $\sqrt{3}{}_f^d V_L \sum_1^{720} i_t$/720 10-3 $\cos\theta \ Kwh$ ....(8)

Now, the voltage is constant though the general over loading in the nation's electricity supply Industry (ESI) has made voltages to be low in some locations. But we shall use **V**/ per phase as 230 volts. Then,

I_{av} amps = $\sum_1^{720} i_t$/720 ....(9)

so that for a single phase energy supply equation,

$Eec = 230 \times 720\ d_f\ i_{av} \cos\theta \times 10^{-3}$ Kwh

and for,

$Pf = \cos\theta = 0.8$ ....(10)

$Eec = 132.5\ I_{av}\ d_f$ Kwh per month ....(11)

and for 3 – phase we have,

$Eec_3 = 229.5\ I_{av}\ d_f$ Kwh per month

The problem is to determine d_f and I_{av} as accurately as possible so that supply authority is fair to the consumer who pays the bills, when there is no meter in his premises, or even when meters are not used or read. In a given example by Nwaoko9, she gave the power in KVA as 156 KVA as the power to be consumed by the consumers and the energy consumed, equation (11), but using pf = 0.85,

$Eec = 156 \times 0.85 \times 24 \times 30$

$= 95{,}472$ Kwh per month (11a.)

on the assumption that $d_f = d_{fv} \equiv 1.0$. But she stated; "It should be noted that the above workings are based on the assumption that the load calculated was consumed for 24hrs per day for 30 days of a month", and perhaps the voltage is 220/230 volts or 380/400 volts, single or 3 – phase respectively as the case maybe. But consider that at a given substation the average diversity factor in (27th June to 19th July, 11am, 2011) is d_{fa}=0.3254; the voltage is 180 V and d_{fv} = 180/230 =0.783, and the assumed power rating used is also 156 KVA. Using these two factors the energy consumed should be 95,472 x 0.782 x 0.3254 =24,294.07Kwh. ....(11b). This is a shocking result of what should have been the case, if the consumer premises were metered. The energy consumed is a linear function of time, so that, o≤ df ≤ 1 and the value of d_f falls between these two extreme factors. For any given consumer this diversity d_f for energy consumed per month is

d_f = <u>Duration Energy was consumed in hours/month</u> ....(12)

Hours per month. (= 720 hrs).

and Ideally, df should be unity (=1.00)

The factors which determine df are many. Some are; routine faults, many not cleared in time, load shedding because of insufficient power flow, deliberate cutting off of supply from certain areas and breakdown of various types of equipment, such as transformers, cables, ring main units (rmu) shortage of primary energy or electric energy production, trees falling on lines, etc. With a very simple instrument, the Hour Meter, the value of df could be computed easily at selected consumer premises so that a more accurate value of energy consumed can be obtained or estimated as shown in equations (11a) and (11b).

It is now left to determine I_{av}. Again, its variation can be ploted against time for durations of one hour, one day, one week or even one month by selecting strategic consumers' premises so as to determine I_{av} for various communities and consumers. In this, for a **PHCN** sub-station, permission can also be used, similar to load reading at the transformer terminals station. The measurements are taken by using a simple clip-on-meter with the time of measurement recorded. Figure 5 showed hour meter and clip-on-ammeter used in the study.

For wider coverage, bed-sitter apartments, room and palour accommodation, two bed room apartments with dinning and without dinning rooms may also be investigated. So also are

buildings in high and low density areas. The results obtained will be useful for the classification of consumers, for the purposes of more accurate bills. Hence these two very inexpensive instruments can be used very easily to obtain comprehensive data on energy consumption for more correct billing of consumers.
The results expressed in tabular forms and graphs with appropriate nomenclature and descriptions are as shown in details in the tables 1 and 2, and figure 6 ....

Simple Probability Approach to Power Supply Reliability
The probability of power supply, P and no power, Q per day, week, month or year is P + Q = 1, for any specified period of time, in each case afore listed.
That is, for a month duration (of 30days) study, week or year, the probability equation is

$T_{pa} / 720 + T_{np} / 720 = 1$ ....(13)

so that,

$P = d_f = T_{pa} / 720$ ....(14)

$Q = 1 - d_f = T_{np} / 720 =$ **....................**(15)

Were,

Fig. 5 Clip-on-ameter and hour-meter used for the study

P = Probability of Power availability/reliability
Q = Probability of no power supply
T_{pa} = Time, hours of power availability/week or month
T_{np} = time, hours, of no power availability/week or month
d_f = diversity factor, and
$\mathbf{T_{pa}} + \mathbf{T_{np}}$ = 720 Hours.

The Simple Measurements Process
Consider that the hour meter was connected in a certain month, and the hours in the month of 30 days = 720 hours but the total hours recorded for the month before the connection of

the hour meter is Hac hours. The hours remaining for the said month is 720 – Hac; so that the corresponding diversity factor for the rest of the first month is

$$d_{fe} - \frac{H_{mi}}{720 - H_{ac}} \quad .... (17)$$

Where, H_{mi} = is the hour meter reading.

For any other additional with month of 30days, equation (17) becomes,

$$\_ \frac{d_{fi}\ H_{mi} + \sum Hami}{-720 \times (i+1) - H_{ac}} ....(18)$$

Where *Hami* = the ith month hour meter reading.
During this measurement of the current I_{av} and the voltage, diversity d_{fv} values (eq 16) and *Hami* hour meter readings should also be taken for the subsequent ith month values. We can also take daily readings of d_{fd}, d_{fv} and I_{av} values respectively, using equation, (18), we have,

$$d_{fd} = \frac{\sum H_{md}}{720 - H_{ac} + 24 \sum id} \quad .... (19)$$

$\sum id$ = the month daily reading, one step at a time on a daily basis
Where H=$_{md}$ the total hours recorded by the hour meter since connection to the time the meter is being read, figure 6. We can plot the graphs for equations (16), (19) and i_{av} per day for one month duration. Table 1 .... shows that correct billing has not been practised; and there is need to give correct bills to consumers. A situation in which those with meters are not even billed according to the meter, is not satisfactory.
The related current values are also shown in table 2, and current values vary depending on the customers load.

Case Studies
An estimated bill of ₦214,753.85 was forwarded to a certain consumer. The d_f and d_{fv} values of this location were 0.3,75, and 0.739 respectively. The estimated energy consumed for one month (over a given period of --------- months) should be

Eec = 132.5 d_f (d_f = 0.375) d_{fv} (= 0.739) K, Kwh. (15)

where K= 1 for more than one month period. The cost of energy consumed is

₦ Ce = ₦ 132.5 d_f(= -------------) i_{av} (= --------------) T_{ov}

Where ....(16)

T_{ov} = operating tariff value, N11.20 energy unit, Kwh.
Other studies table 2 showed the comparison between the bills received from **PHCN** and some consumers investigated in this study. Two of the consumers had no meters; the bill was estimated, hence it was too high.

TABLE 1 some **PHCN** Bills compared with Results of this study.

S/NO	Location	PHCN Bill, ₦	This Studies' Bill Estimate, ₦ x d_fx d_{fv}	
1	Sample A	214,764.85	59,516.43	No meter
2	Sample B	276,466.63	276,466.3	Metered x 1
3	Sample C	95,472	24,294.07	No. Meter.

Table 2 shows the values of d_f, i_{av} and d_{fv}, hence the effects of the low voltage supply d_{fv} are now also taken into account in this typical study.

TABLE 2 Values of d_f , i_{av} and d_{fv} = $V_c/230$

S/NO.	Location	d_f	i_{av}	d_{fv}	Remarks
1	Rural Communities	0.518	2.6A	0.70	Rural setting
2	PHCN Sub/Station	0.375	7.3	0.739	Sub/station
3	Ughelli-Tenant	0.447	3.1	0.739	Tenant
4	Ughelli-Tenant	0.447	3A	0.652	Tenant

Fig. 6 shows the variation of d_f and d_{fv} for a typical month. The results are matters of serious concern to us all.

Estimate Billing Concept

The concept of estimate billing for sending bills to consumers of electricity by PHCN without adequate metering should be reviewed soonest. Estimate billing has negative effects on the customers as well as on the staff of any supply authority. On the customers, the tendency not to pay the bill is there especially when the supply is irregular. How can one pay a bill that is thrice the amount one will pay if the supply is regular? This has led to accumulated bills that are unpaid by the consumers and this practice is coursing the even mounting unpaid bills to PHCN. The staff on the other hand are also affected. The rate at which they respond to customer complaint is reduced. It takes days if not weeks to clear a simple fault that ordinarily would have taken some few hours. The reason is that whether there is supply or not at the end of the month, customers will receive estimated bills. This then breads laziness on the part of the staff concerned. Estimate billing has also increased the corruption level of the staff. Since sincere consumers would want to pay his/her bills which are quite high, the tendency to bribe the marketer with a token so that the lot can be "wiped off" the bill, this corrupt archive has become a constant feature in the life of some marketer. These observations are for now important. However, there may be need for more detailed study of the concept so that sometime in the future it can become a thing of the past.

CONCLUSION

Power supply using tariffs with meters have been examined in this paper. The results show that arbitrary bills are forwarded to consumers to pay and when there are no meters' and sometimes there are meters but they are not read. It is necessary to re-do the bills to consumers who do not have meters. Some more work is in progress so as to arrive at much more correct electricity bills to the consumers with no meters or if meters are not read. We have torched on a wider topic of billing consumers without any errors; and without meters; for correct metering is crucial so to establish confidence between the customer and the power supplier.

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