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# Wireless Intelligent Electricity Metering and Billing System (WIMBIS)

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## Abstract:

This paper presents a novel smart meter design with a focus on the peculiarities of energy metering and billing challenges in Nigeria. The smart meter can be remotely configured at the control centre to work in either pre-paid or post-paid mode which allows for flexibility for various types of customers. The microcontroller based meter communicates with the energy company control centre via SMS using the embedded GSM Module. Using an LCD display or the globally accessible web based portal, the customer can track and manage their energy usage according to their financial means.

*Keywords* — **Advance metering, smart electrical meters, energy monitoring, automated meter reading, GSM**

## INTRODUCTION

Our modern day society is highly dependent on electrical energy for the provision of personal comfort and for diverse productive purposes in industries [1], [3]. Electricity is the bedrock of a nation's socio-economic development, and in recent times, the sufficiency of the electrical energy generated for the needs of the populace has become a vital index of national development [4], [5]. In Nigeria, the power sector is faced with multiple challenges ranging from insufficient generation, inadequate power transmission and distribution system, poor maintenance, insufficient investment for capital projects, energy theft, waste of energy, energy metering and accurate billing inadequacies, non-payment for used energy etc. [6], [7].

The power sector was privatized in 2013 to stimulate its rapid growth and to drive private sector investment as a pathway for sustainable development. Sadly, as at 2018, a significant difference between the pre and post privatization in terms of service and power reliability is yet to be experienced by the populace. Power generation is grossly inadequate and the metering and billing of the insufficient energy generated is a major issue every month for the Distribution Companies (DISCOs).

Nigeria is a developing country with about 46% of the populace living below the poverty level [8], and as such energy theft and non-payment for used energy is a common trend. This creates a major issue for an energy sector that is already poorly financed. The power sector requires good cash flow to maintain the currently available insufficient facility to prevent total system collapse. Consequently, an undesirable situation in which some customers are billed above their actual energy usage in order to compensate for energy theft and also ensure that energy dispensed is paid for by someone is a common practice by DISCOs. To check this trend, the Nigerian Electricity Regulatory Commission made effort to ensure the installation of pre-paid meters for both domestic and industrial energy customers as a way of checking the exorbitant charges for unused energy commonly termed "crazy bill". Due to funding challenges pre-paid meters are yet to be deployed to most customers and DISCOs have proposed that willing customers can personally procure a pre-paid meter and the concerned DISCO will pay the customer back with energy.

## I. LITERATURE REVIEW

The power consumption of the teeming Nigerian population is current metered in two ways:

1. The bulk of the customers are on the traditional spinning disk meters which are physically read every month by DISCO personnel who log the reading in a notebook and presents the record at the Branch office for bill processing. The bill is generated and

later dispatched to customers for payment. This post-paid process is archaic, time consuming and cost intensive, and cases of erroneous reading, metering personnel skipping customers or generating reading based on previous readings (estimated bills) and also instances of illegal transactions between customers and DISCO personnel so as to reduce energy bills have been observed. A number of bills are usually lost in transit and those who do receive the bills, have to go to a nearby office to effect payment, which may be difficult for customers who work far away from home and are only available on weekends. Customers who fail to pay their bills are disconnected from the supply and this requires that a team of technicians mobilize to such locations with tools and equipment, moving from one building to another in order to effect the disconnection using ladders. Often the disconnection teams are physically attacked and may require security escort. This approach of metering and billing is rather inefficient [9].

2. A percentage of the customers are on pre-paid meters but cases of meter bypass have been reported. The DISCOs are trying to check this by imposing a heavy fine on any customer that is caught by periodically sending out inspection teams. The reality is that a number of households are fenced and the inspection team often cannot access the meter to check for any tampering or meter bypass. The prepaid meters currently available in Nigeria are recharged with energy units purchased at DISCO vending stations. The energy is dispensed in kWh, and the unit purchased is issued as codes on a paper slip. The code will be entered by the customer to recharge the prepaid meter. This mode of recharge requires establishing several vending stations for easy access by customers and this increases operational cost.

A percentage of distributed energy is lost through energy theft, unmetered customers, unpaid bills and line losses and these losses are generally termed Aggregate, Technical, Commercial and Collection losses, and this was about 50% before 2013. The causal factors, the different methods and the effects of energy theft were studied and analysed by [10] that proposed the use of harmonic generators for generating undesirable harmonics within the distribution network, specifically targeted at identified energy thieves' equipment.

According to [11], [12] an optimal energy payment structure can be achieved by establishing two-way communication between the energy meter and the control centre for direct billing and energy purchase, though this may be challenged by internet connectivity issues. In this study, a model, dual mode (pre or post-paid) energy meter is designed and implemented. The energy monitoring, billing and payment is achieved via readily available Global System for Mobile Communications (GSM) network using SMS. This energy meter will eliminate the need for physical meter reading, reduce the number of DISCO branch offices, as only a few data processing centres will be required for meter monitoring, billing and recharge purposes.

An electrical energy meter is a device that accurately measures the energy consumption of the load network to which it is connected. Generally, energy meters can either be of the electromechanical kWh type or the electronic type [13], [14]. Using the electromechanical meters for the traditional mode of billing and payment is quite inefficient and this triggered the development of prepaid and smart meters to curb the identified inefficiencies.

Smart meters are advance meters with improved energy consumption tracking and other features such as the ability to communicate with monitoring centres, tamper proof protection, load profiling etc. In [15] a microcontroller 89C51 based prepaid meter was developed; the meter energy unit is loaded via a magnetic credit card using a magnetic strip card reader. This model does not incorporate any means of two way communication. The study by [16] proposed a meter design that grants the utility centre direct access to each of their customer's meter for energy consumption control. A post-paid smart meter was developed by [17] using ATMEGA 16 microcontroller; the smart meter is uniquely identified using an RFID module.

Energy consumption is sent to a master station where the bill is automatically computed and sent back through IEEE802.11 interface to the Zigbee module in the smart meter on 802.11 protocols. A method of using cameras placed in front of the energy meter to snap the meter readings on a specific date each month was proposed by [13], the image is processed by Matlab to extract the figures and this is used to compute the bill for the month. The bill is then sent via SMS to the customer through the GSM module installed in the meter.

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## II.METHODOLOGY

Since the advent of GSM communication in Nigeria in 2001, the network coverage provided by four major operators spans the length and breadth of the country, hence GSM can serve as a platform for easy smart meter communication with various master stations across the nation.

This implemented model is a microprocessor based design [18]. In this design communication is achieved via low cost SMS using GSM modules. The prototype is designed to fully automate the metering and billing process. Each customer is assigned a smart meter with a unique ID (SIM card), and the specific information of each customer such as full name, telephone number and email are stored on a central server. The operational process is described in figure 1.

With respect to figure 1, 9 is the post/prepaid meter in a customer premises, the meter links to the GSM network via a SIM card through signal 4, the signal is received by a local DISCO office through signal 5 where a software is running to determine the status of the received signal, either post or prepaid arrangement. The software automatically process the kWh consumed by the utility and prepares a bill in the case of a postpaid arrangement. The bill is wirelessly sent back via same signal route to the LCD interface of the meter as well as the mobile handset of the subscriber anywhere he or she is via signal 1, the calculated bill is equally forwarded to the central server (database) at the HQ of the DISCO for record purposes as well as planning.

The recipient of the bill in 1 or at the LCD interface can either buy a DISCO scratch card of equivalent amount, or pay to the financial homes as convenient, the financial homes report payment via signals 3 and 8 through the local DISCO servers which authenticate the utility meter and enables it to continue working. On the other hand, if payment is not done within stipulated time, the power supply in the house is automatically cut off without human interferences.

On the prepaid mode, a subscriber can buy a scratch card of his choice (value) and load on the meter by sending the amount to a special GSM number with an appropriate code. This will automatically authenticate the meter to start working until the unit runs down. The implemented and lab tested dual mode meter is shown in figure 4.

The meter control process is depicted by figure 2 and figure 3. To deactivate the smart meter after a failure to make payment (post-paid) or when the unit is exhausted (pre-paid), a unique code is automatically sent to the SIM Card in the Smart Meter's GSM Module, once it receives the code, the code is processed and the power supply is automatically cut off as shown in figure 3.

Once payment is made by the customer and authenticated by the DISCO servers, a unique code is sent to the smart meter to activate it. On receiving the SMS code the smart meter immediately restores power to the household without any human involvement [19].

The advantages of the system over conventional available meters are obvious;

- It eliminates human interference and error (M2M) [20].
- It eradicates human work hours distributing bills to every utility in town
- There is no need of army of meter readers moving out monthly to generate bills
- It actually eliminates the need to carry ladders around to disconnect and connect the electricity wires of customers who default in the payment of their electricity bills from the poles.
- It encourages planning, as a regional consumption value in kWh can easily be calculated and used for future planning.

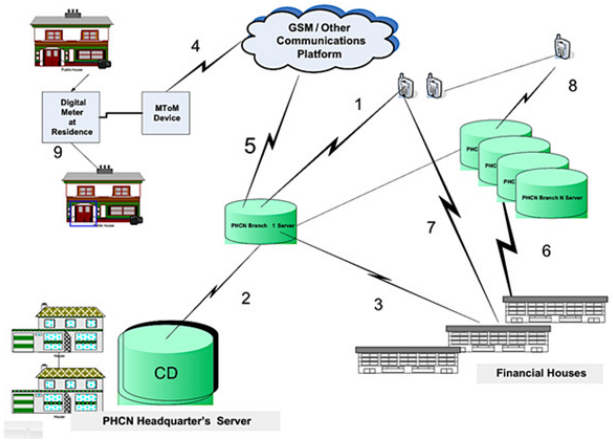


Fig. 1The Metering and Billing Process

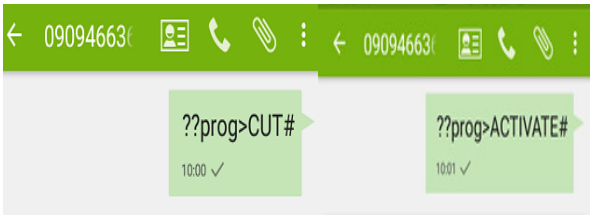


Fig. 2The Power Cut-off and Activate Instructions


Fig. 3The Disconnected and Connected Meter Operational State

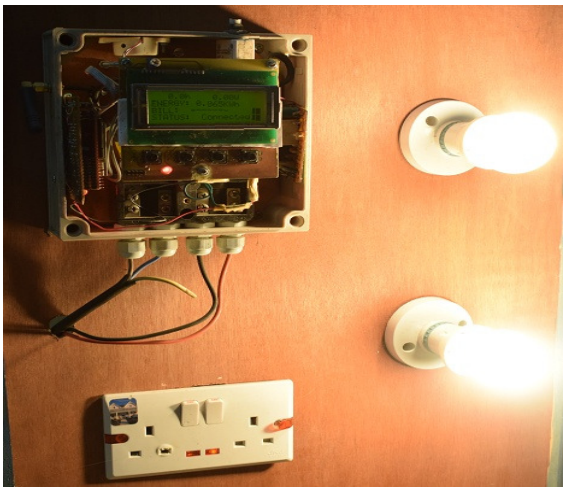

Fig. 4 The Implemented Design

## CONCLUSION

Our world is energy driven and with the current advancement in technology, there is a corresponding growth in energy demand. Accurate and cost effective energy metering is a challenge globally with severe implications on energy revenue collection in developing countries. This research implemented a microcontroller based smart meter using low cost SMS for two way communication between the meter and control centre. GSM network coverage is virtually all over Nigeria which makes it easy to deploy the design nationwide. The design was implemented and tested with various loads at the lab to determine its accuracy and effectiveness. The test results confirm meter functionality, accuracy and efficiency. The meter can be used in dual mode, and the online web portal allows customers' easy access to their energy usage and recharge history.

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