

Design and Implementation of an Enhanced Power Billing System for Electricity Consumers in Nigeria

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ABSTRACT

In Nigeria, electricity consumers are often faced with the problems of inaccurate, irrational and delay in monthly billing due to the drawback in reading pattern and human errors. Thus, it is essential to have an efficient and effective system for such purposes via electronic platform with consideration to proximity. This paper presents the design and functional significance of a web-based application with online capability called Power Billing System (PBS). PBS is a solution system developed with Microsoft Visual Web Development IDE; being an Object Oriented Design tool from Microsoft Visual Studio.net collection and Microsoft Access with SQL query for back-end database. It measures accurately the electric power consumed by residential or commercial buildings which is more economical compared to the electro-mechanical devices. Individual consumer and the utility companies can directly monitor and control electric power supply billing without engaging the services of meter readers. It displays the sale rate of electrical power per unit and the consumed power per minute. It provides environment to maintain the consumer details right from connection and performance information to the management. It is an Intranet and Internet based software solution that ensures timely availability of status parameters.

Keywords: Power Billing, Electronic System, Electricity, Meter Reading, Consumers, Database

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1.0 INTRODUCTION

Power Billing System is an Executive Information System (EIS) that determines the consumed power per unit time and performs its computation based on the sale rate of power per unit time and other parameters. The importance of Power Billing System (PBS) 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 (Advalorem, 2009).

It provides an environment to maintain the consumer details starting from getting new connection, receiving bill, payments etc; access to performance information by the management (Seshanna et al, 2006). It functions on an Intranet network and Internet domain and ensure timely availability of status parameters. The ability to view the reports online ensures access to the report from PC terminal or devices VLAN and WAN network with internet connection. Customers can lodge complaint or deal with new connections just by logging into the system.

In the traditional system, files were used to maintain the database which was done manually. This existing system consumes a lot of time. This time consuming evaluation coupled by the huge maintenance problem and also leads to erroneous results in most cases. The various operations performed on these files by the personnel of Power Holding Company of Nigeria (PHCN) like sorting, adding, modifying and deletion of the records are very tedious. Moreover, these manually maintained files have the possibility of getting worn out. Thus, less durability, reliability, privacy, prioritization and efficiency is achieved.

2.0 PROBLEM ANALYSIS

Electricity is the science, engineering, technology and physical phenomena associated with the presence and flow of electric charges. Electricity gives a wide variety of well-known electrical effects, such as lighting, static electricity, electromagnetic induction and the flow of electrical current in an electrical wire (IEEE, 2008). In addition, electricity permits the creation and reception of electromagnetic radiation such as radio waves. In electricity, charges produce electromagnetic fields which act on other charges (Franklin, 1869). Priestley (1967) Electricity remained little more than an intellectual curiosity for almost a millennium until a careful study of electricity and magnetism, distinguishing the lodestone effect from static electricity produced by rubbing amber (Bryon, 2002). Alessandro Volta's battery, or voltaic pile, of 1800, made from alternating layers of zinc and copper, provided scientists with a more reliable source of electrical energy than the electrostatic machines previously used (Abubakar, 2009).

The recognition of electromagnetism, the unity of electric and magnetic phenomena; electricity and magnetism were eventually linked. The **Power Holding Company of Nigeria (PHCN)**, formerly the National Electric Power Authority (NEPA) is an organization governing the use of electricity in Nigeria. Despite the problems faced by NEPA, the authority has played an effective role in the nation's socio economic development thereby steering Nigeria into a greater industrial society. The success story is a result of careful planning and hard work. The statutory function of the Authority is to develop and maintain an efficient co-ordinate and economical system of electricity supply throughout the Federation.

The decree further states that the monopoly of all commercial electric supply shall be enjoyed by NEPA to the exclusion of all other organizations. This however, does not prevent private individuals who wish to buy and run thermal plants for domestic use from doing so. NEPA, from 1989, has since gained another status-that of quasi-commercialization. By this, NEPA has been granted partial autonomy and by implication, it is to feed itself. The total generating capacity of the six major power stations is 3,450 megawatts. In spite of considerable achievements of recent times with regards to its generating capability, additional power plants would need to be committed to cover expected future loads.

At present, plans are already nearing completion for the extension and reinforcement of the existing transmission system to ensure adequate and reliable power supply to all parts of the country. The existing system is a billing machine that constitutes five divisions but, too overburdened, less flexible, slow pace of processing and not so user's friendly. Fig. 1 gives the overall block diagram of the computer-based power billing machine with the highlighted shortcomings. This is an electro-mechanical meter system used to measure accurately the electric power consumed by a company or an individual.

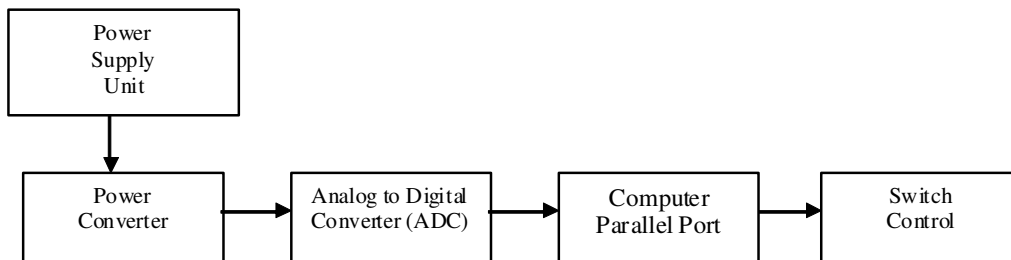


Fig. 1 Block diagram of power billing machine

2.1 Consumers Classification

Consumers are classified based on their mode of consumption and by tariff classification. Tariff measures; defined as electric tariff at which the energy is selling to the consumers (Ghoshal, 1997). Usually electricity tariff are fixed by Government. Tariff at the moment are categorized into residential, commercial, industrial, street light and special tariff. The special tariff is agro-allied enterprises, Government and teaching hospitals, water boards, secondary and tertiary Institutions. The tariff for each category is fixed by voltage class (Abubakar, 2009). Tariff is calculated by kilowatt hour. For industrial and commercial or other consumers, receiving transformer with a capacity of 100 KVA or more, who have electrical equipment installed, receiving capacity of 100 KW or more; their tariff comprises two components, these are Kilowatt hour tariff (calculated on the basis of actual use) and basic electricity tariff (based on the consumption capacity).

Table 1: Residential Class

| Class | Demand Level | Demand Charge/Kva | Minimum Charge/Month | Fixed Charge | Meter Maintenance Charge | Energy Charge/Kwh |
|--------|------------------------|-------------------|----------------------|--------------|--------------------------|-------------------|
| R1 | < 5kVA | 0.00 | 31.00 | 31.00 | 154.00 | 1.30 |
| R2 | $\geq 5 < 15$ KVA | 0.00 | 46.00 | 46.00 | 154.00 | 4.40 |
| R3 | $\geq 15 < 45$ kVA | 0.00 | 185.00 | 185.00 | 772.00 | 6.60 |
| R4(MD) | $> 45 < 500$ kV A | 0.00 | 7,716.00 | 185.00 | 2,469.00 | 9.40 |
| R5(MD) | $\geq 500 < 2$ M VA | 0.00 | 48,228.00 | 0.00 | 3,395.00 | 9.40 |

Table 2: Industrial Class

| Class | Demand Level | Demand Charge/Kva | Minimum Charge/Month | Fixed Charge | Meter Maintenance Charge | Energy Charge/Kwh |
|-------|--------------|-------------------|----------------------|--------------|--------------------------|-------------------|
| D1 | >5<15kVA | 00.00 | 136.00 | 136.00 | 151.00 | 7.90 |
| D2 | >15<45kVA | 00.00 | 181.00 | 181.00 | 755.00 | 10.30 |
| D3 | >45<500kVA | 278.88 | 7,550.00 | 362.00 | 2,416.00 | 10.30 |
| D4 | >500<2MVA | 303.13 | 47,188.00 | 0.00 | 3,322.00 | 10.30 |
| D5 | >2MVA | 327.38 | 2,265,011.00 | 0.00 | 3,322.00 | 10.30 |

Table 3: Commercial Class

| Class | Demand Level | Demand Charge/Kva | Minimum Charge/Month | Fixed Charge | Meter Maintenance Charge | Energy Charge/Kwh |
|--------|--------------|-------------------|----------------------|--------------|--------------------------|-------------------|
| C1 | >5<15kVA | 00.00 | 138.00 | 138.00 | 153.00 | 7.40 |
| C2 | >15<45kVA | 00.00 | 184.00 | 184.00 | 767.00 | 9.70 |
| C3(MD) | >45<500kVA | 262.53 | 7,673.00 | 368.00 | 2,456.00 | 9.70 |
| C4(MD) | >500<2MVA | 328.13 | 47,959.00 | 0.00 | 3,376.00 | 9.70 |

Table 4: Street Lighting Class

| Class | Demand Level | Demand Charge/Kva | Minimum Charge/Month | Fixed Charge | Meter Maintenance Charge | Energy Charge/Kwh |
|-------|--------------|-------------------|----------------------|--------------|--------------------------|-------------------|
| S1 | 1-PH, 3-PH | 0.00 | 312.00 | 0.00 | 651.00 | 5.90 |

3.0 METHODOLOGY

The major specification in this design allows the system to capture data related to consumer's profile in order to assign an identification code with which transaction relating power billing, meter request, complaint. It constitutes various modules among which administrator and consumer module are integral. Consumer is granted access only through the username and password created from first visit to online system or when registering at the web portal, in orders to utilize the features available to consumer from remote terminal. The administrator module is handled by an authorized PHCN employee, in order to grant request relating to customers' service, validate every transaction online or to confirm payment via electronic system and to review consumers' profile, revert an action, track connection and billing status. The functional requirements of this application were analyzed from the data contained in the existing system; inputs like business information, service stations and the data contained in the outputs like the bills, ledger and receipt.

Formal model of the proposed system is presented in flowchart and context diagrams. All these models will give the conceptual view and to provide the graphical analysis of users' requirements. As a major modeling tool, entity relationship diagrams helped in organizing the functional elements of the system into entities and also define the relationships between the entities. This process enabled the analyst to understand database structure so that data can be stored and retrieved in a most efficient manner. Flowchart showed the flow of data from external entities into the system. It also showed how data moved from one process to another as well as its logical storage. Figure 2 shows the operational modalities that guides input-output process via users' interface while Figure 3 shows the major activities of the consumers and integrated into web portal and as online system for electricity supply and bill distribution, and as well as the automated interactivity of the consumers' module in validating users' input.

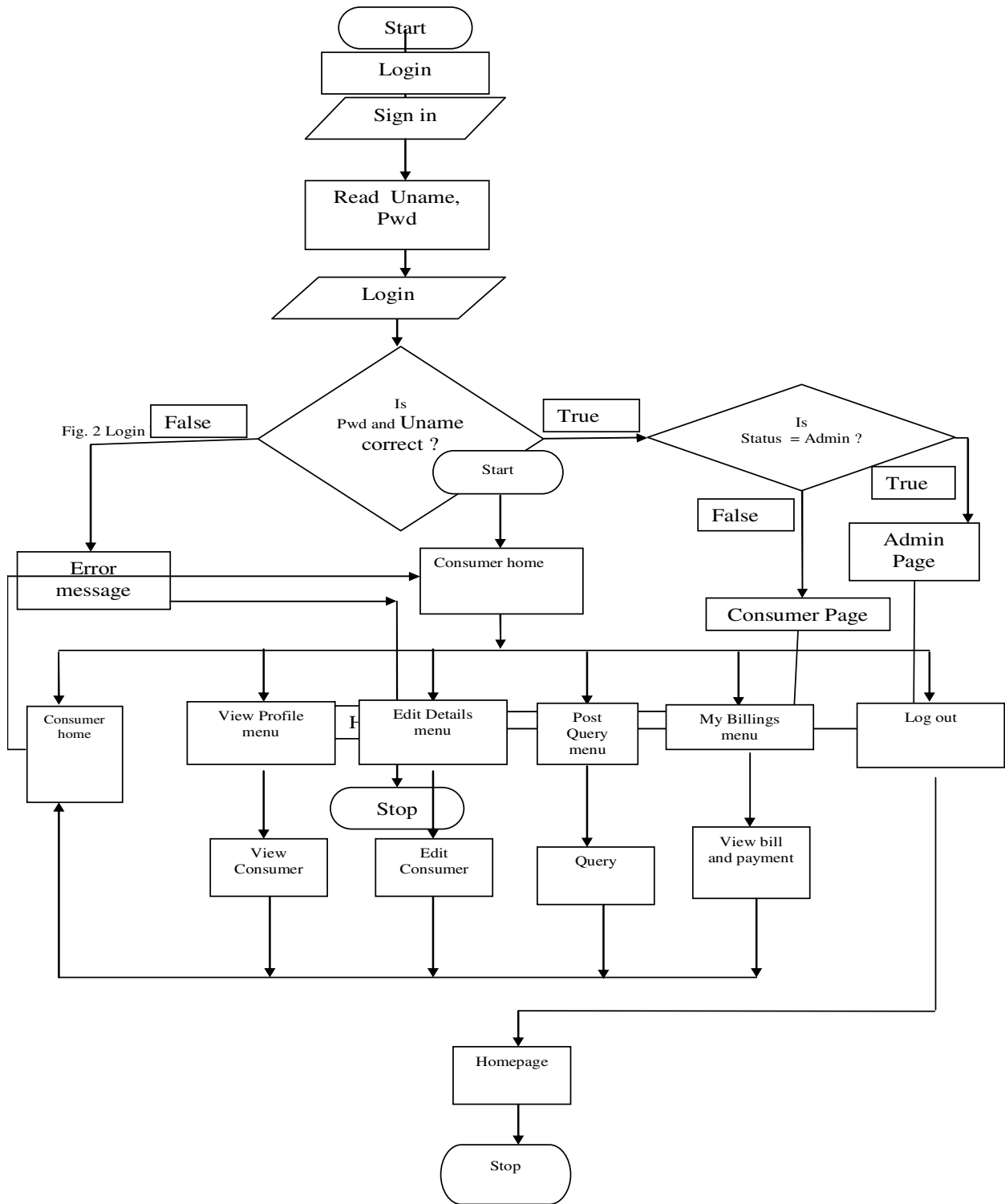


Fig. 3 Consumers' Activity Flowchart

4.0 IMPLEMENTATION AND RESULTS

The implementation was done using Microsoft Visual Web Developer and Access Database with SQL support for back-end application. The System captures Information related to actual demand, energy usage, payments, exceptions etc. from various levels of organization with the aim of capturing it from as close to the source as possible. The application basically starts by displaying the homepage. Thereafter, username and password are requested for the specified status (i.e. consumer or administrator). Validating the username and password in order to proceed or not. During the integration testing, the following outputs were obtained according to design modules; in order to describe and analyze the functional scope and performance evaluation of Power Billing System (PBS).

1. **Meter:** Enables the administrator to add and view consumer meter by providing the circle name, division name, meter company name and the meter I.D, If the meter I.D matches with another I.D in the database, it will prompt an error indicating that the I.D. cannot be used.



Fig. 4: Meter Registration Screen

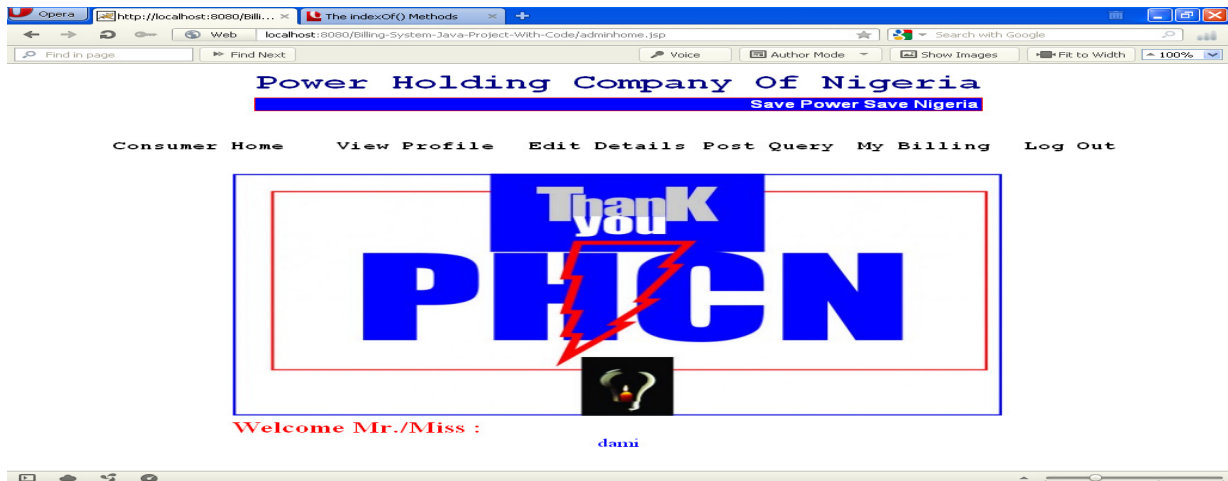


Fig. 5: Consumer Home Screen

2. **Billings:** Enables the administrator to send bills to consumer by selecting the connection type and consumer meter number. Note, consumer cannot be billed more than once in a month.



Fig. 6: Select Connection Screen

3. **My Billing:** This session enables user to make bill payment by providing a card number. If this card number is invalid then the system will prompt an error via merchant and EPS support.

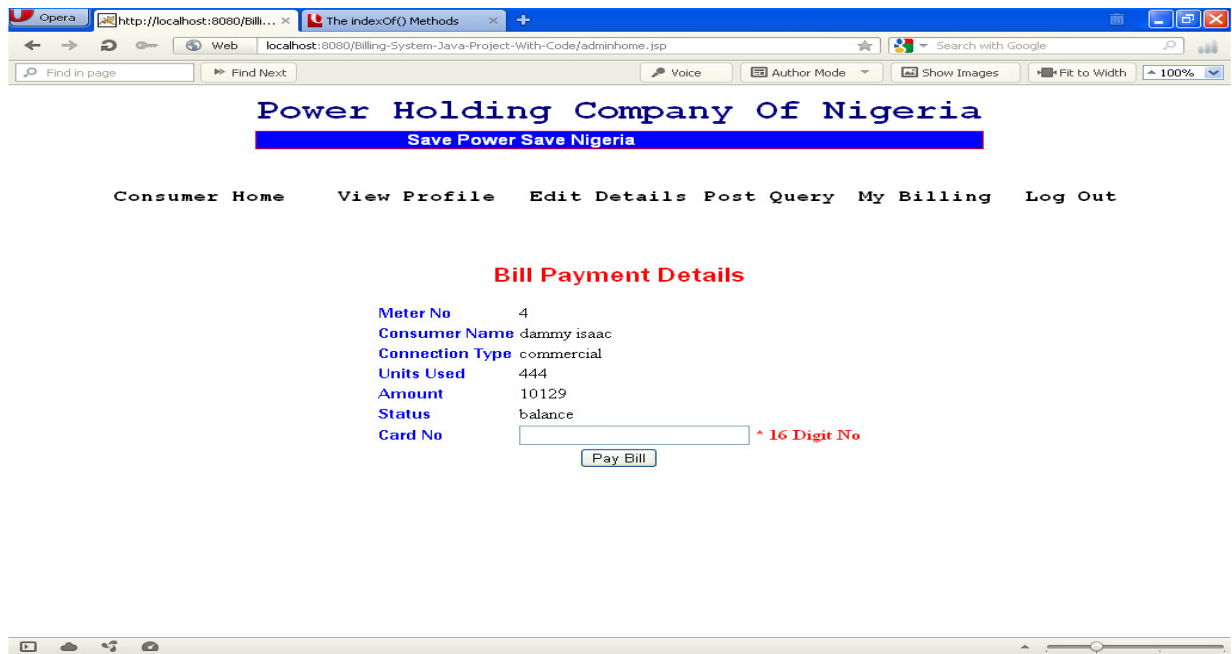


Fig. 7: Payment Screen

4. **Post Query:** Allows consumer to post complaint to the administrator by clicking on the Post Query menu and to type their query or comment in the textbox provided on the page.

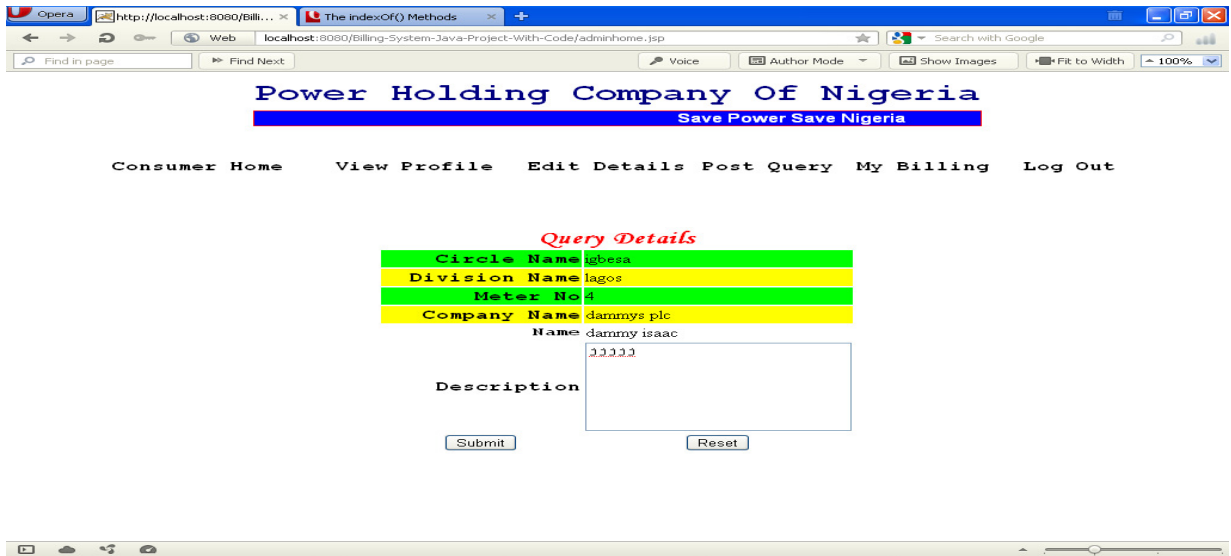


Fig. 8: Post Query Screen

5. **Admin Login Session:** Enables the administrator to have access to the system via username and password. If the password or username entered is wrong, then the system will automatically display an error page indicating that the username or password is incorrect.



Fig. 9: Admin Login Screen

6. **View Query:** Enables the administrator to view consumer complaint. This is achieved by clicking on the View Query menu.



Fig. 10: View Query Screen

5.0 CONCLUSION

Usability testing was part of post implementation review and performance evaluation for Power Billing System (EPS), in order to ensure that the intended users of the newly developed system can carry out the intended tasks effectively using real data so as to ascertain the acceptance of the system and operational efficiency. It caters for consumers' bills and also enables the administrator to generate monthly reports. It is possible for an administrator to know the consumers that have made payment in respect of their bills for the current month, thereby improving the billing accuracy, reduce time consumption and workload on PHCN employees or designated staff, increase the velocity of electricity distribution, connection, tariff scheduling, eliminates variations in bills and replenish based on market demand. The conceptual framework allows necessary adjustment and enhancement maintenance to integrate future demands according to technological or environmental changes with time. It manages the consumers' data and validates their inputs with immediate notification to users at remote locations; centralized in PHCN offices across the nation.

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