OBSERVATORY SYSTEM FOR MONITORING ELECTRIC POWER DEMAND AND DELIVERY

A thesis submitted to the faculty of Computer Science at African University of Science and Technology In Partial Fulfillment of the Requirements for the Degree of Master of Science in Computer Science.

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CERTIFICATION

This is to certify that the thesis titled “Observatory System for Monitoring Electric Power Demand and Delivery” submitted to the school of postgraduate studies, African University of Science and Technology (AUST), Abuja, Nigeria for the award of the Master's degree is a record of original research carried out by Ajayi Tunde Oluwaseyi in the Department of Computer Science.

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ABSTRACT

Nigeria is a fast-growing country in terms of urbanization. One of the major infrastructure challenge is power supply. However, this challenge is often not as a result of power generation but as a result of power distribution. It is expected that housing development policies be implemented for example through standard for house equipment. The partners are expected to be ministries of power, works and urban development. This report is a documentation of a project which required developing an Information system (Observatory) that makes available, online statistics of Electric Power Demand. The statistics provided will serve as a decision-making tool for policy makers in the relevant sector to plan optimal strategies for better delivery of Electric power, especially in the area of provision of Electrical Infrastructure. The development of the Information System was achieved using Drupal Content Management System.

Keywords: Observatory; big data; dashboard; decision-making; indicators; information system; information visualization; electric power; demand; delivery; competitive intelligence; drupal, CMS

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To my friends,	thanks for being there.
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Chapter one

Introduction

1.1 Motivation

A common knowledge is that Electric power cannot be stored. Unlike some other sources of energy like gas, which can be compressed and stored in cylinders, Electric power cannot be contained. It has to be supplied to consumers as it is being generated, so as to meet the immediate needs of the end users. The Electricity consumers may include residential, industrial or commercial users. It is common practice to locate Electric Power Generating Companies, commonly referred to as GENCOs, far away from residential areas, hence transportation of electric power is done at a very high voltage after being generated, over long distances, to the users in order to meet their demands. More so, energy loss is recorded in the course of transmission from the GENCOs, which explains the disparity between values of Electric Power generated and that which is being transmitted.

Expensive equipment such as transformers, wires and even electrical substations are needed to generate and distribute electric power. It is not uncommon to see Electrical substations being overloaded or under-utilized as a result of lack of proper statistics of the demands on them. The demand for electric power by both residential, commercial and industrial users have been on the rise given the existing infrastructures and the improvement in technology, considering that demands vary greatly among the mentioned end users. Due to the disparities observed in the consumption of power delivered to them at different points in time, there is the need for a system to observe the interplay between Electric power delivered to end users and the Energy which was actually consumed by the said users. Such Observatory system is needed to provide visualization of valid statistics of relevant Indicators.

1.2 Aims and Objectives

The primary aim of this project is to design an Observatory System that will accept and store data that pertains Electric Power Demand, and provide visualization of information obtained from analysis of such data.

The project will proffer possible strategic decisions that can be taken by policy makers in the Energy sector from the information obtained from usage of such Observatory system with the aim of highlighting its significance and relevance, even to other application domains.

1.3 Challenges

The only challenge which might be encountered in the course of carrying out this project is that of time constraint. The combined process of project documentation and the implementation of the proposed system can prove to be quite tasking.

1.4 Expected Result

It is expected that at the end of the project, an observatory system should have been designed with Drupal Content Management System to monitor the adequacy of the standards and reality of Electric power demand. This should help stakeholders adapt the policy that will help in strategizing the infrastructural development in terms of provision of electric power. The system should be an online system, such that it can be accessed from anywhere in the world.

1.5 Scope/Limitation

The proposed system would not be automatic. Test data would be manually fed into the database. No sensor of any kind would be required to automatically detect and transfer data to the information system.

Also, the Test data to be used to design the system would not be of incredible volume in the sense of Big Data. Rather, the system would be scalable, flexible to accommodate more data as the need arises.

The system would not perform any sort of computational predictive analysis, rather the statistics obtained from the Observatory could be useful to the necessary stakeholders in carrying out energy consumption forecast, given the appropriate parameters.

The scope of the Content Management System is restricted to Drupal version 7, to design and implement the proposed system. The latest, version 8, is still in its experimental phase.

Chapter Two

Literature Review

2.1 Introduction

Power, which is the interplay of current and voltage plays a vital role in defining energy consumption. Electric energy consumption is simply the rate of using electricity (which can also be referred to as the Demand for Electricity). This is measured in kilowatt-hour, kwh. For instance, two 60 watts can consume in one hour, 120 watts or 0.12 kw. Thus, the energy consumption would be given as 0.12 kwh for the two 60 watts bulbs.

There exists relationship between energy consumption and economic growth. Energy commodities facilitate sustainable economic growth and development by raising the level of productivity, improving income as well as paving way for opportunities. (Bright & Machame, 2011)

The cost of generating and distributing electricity plays a major role in determining how cheap electricity supply would be for both economic and social development. It is a known fact that especially from data obtained from Energy Information Administration, EIA, that though electricity generation has increased over the years, same can’t be said for electricity supply or consumption when compared with other countries like South Africa, India, Brazil etc.

An unidentified factor that drives energy demand is population. Prediction of explosive growth in world population is perceived to be at an alarming exponential rate according to United Nations Population Division. With time, this population increase will result to a greater demand and consumption of electricity, which will in turn affect the economic growth.(Gonen, 2014)

2.2 Review of Electric Energy

Energy is very important for the existence all humans on earth. In fact, life on earth has greatly improved with advancement in technology of electric power delivery. The need for speed in related aspects of life such as Transport, Communication, and Manufacturing processes, has further led to an increase in demand for electrical energy. Irrespective of the forms in which electric energy is demanded, either in heating applications or being used in electric motors in industries, even at home for lighting purposes or for transportation systems, it is still the most popular form of energy.

There is notable comparison in the status of nations with their advancement measured in terms of their per capita consumption of electrical energy, that is to say, how many kilowatt-hours consumed per person per year. The statistics is stated as India (about 300) with United Kingdom having twelve to fifteen times more than India and USA is said to have thirty times more than India. (B. L. Theraja, 1999) The reason for the popularity of electric energy is not far-fetched, some of which include:

Electric energy leaves little or no trace of environmental pollution when being used. Most other forms of energy leaves in the wake of their usage lots of environmental pollutants which can be harmful to the environment. Unlike some other forms of energy like Nuclear energy, electric energy can be controlled. The risk of electrical operations getting out of hand is nothing compared to that of other energy forms. In considering health hazard, electric energy poses minimal health risk. Other energy forms emit pollutants, contaminants, and other radiations which are hazardous to health.

Transmission of large quantities of electric is possible, at a considerable speed, over long distances. This increases its popularity as it is accessible even in remote locations. If electric energy is needed in diverse forms, various equipment is readily available to transform electric energy into forms that appeal to the intended user. It is therefore not incorrect to point out that all of the aforementioned reasons and more, increases the reliability of electric energy.

2.3 Review of Power System

For a nation to be classified as being developed, given its population and existing level of technology, there should be an economic balance sufficient enough to cater for its present and future need. Stable power supply is one of the numerous technological factors that determine how developed a country could be. World powers like USA and Russia have tapped into this discovery and utilized it to their advantage, that is why they still retain the status quo.

Before power gets to the final consumer, it passes through the process of generation, transmission, and distribution. For this to take place effectively is the need for substation as power passes through different voltage levels in the process.

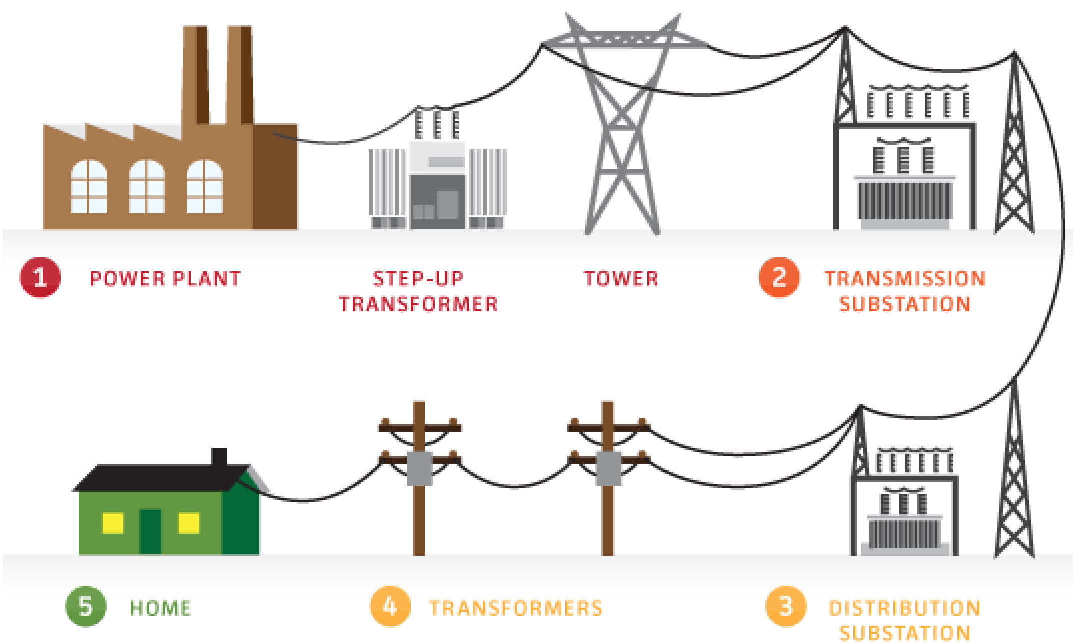

Figure 1: Electric power delivery Source: google image

Substation generally is an assembly of apparatus designed to change the characteristics of a power system. These characteristics can be voltage, frequency, power factor. In a 33/11kv substation, voltage is the variable of interest, i.e. changing it from 33kV to 11kV. The major component used to achieve this is called a transformer. This substation will have different 11kV outgoing feeders going to different load areas. Thus, the substation is mainly to inject power to these feeders when desired. That is why it is called injection substation.

It is common practice now-a-days to interconnect many types of generating stations (thermal and hydroelectric etc.) by means of a common electrical network and operate them all in parallel. This combination of generating stations forms what is known as ***Power system***. The various elements of such a system like generating stations, transmission lines, the substations, feeders and distributors etc. become tied into a whole by the integrated process of continuous generation and consumption of electric energy.

Voltages found on the distribution network can fall into the range of 33kV-415/230kV as the case may be, comprising of medium and low voltages. The distribution system may be divided into feeders, distributors, and service mains. Feeders are the conductors which connect the substation to the distributors serving a certain allotted area. (Folarin, Sakala, Matlotse, & Gasennelwe-jeffrey, 2017). From distributors various tappings are taken. The connecting link between the distributors and the consumer's terminals are the service mains. The essential difference between a feeder and a distributor is that, whereas the current loading of a feeder is the same throughout its length, the distributor has a distributed loading which results in variations of current along its entire length. In other words, no direct tappings are taken from a feeder to a consumer's premises.

2.4 Review of Information System

A System, in general term, consists of components that are related in some ways. They produce desired output through combined effort. A Computer system for instance, is made up of the Hardware and Software components, which together with the Human components achieve a desired result.

Information System in an organization is perceived as components put together to capture and manage data in order to help produce information that is of immeasurable value and benefits to the organization, its partners and even its customers. (Whitten & Lonnie D. Bentley, 2007)

Basically, the activities of an Information system include: data collection and storage, documentation and most importantly, making Intelligent decisions from that which is obtained from processed data. The I-V-C model is an approach suggested to effectively use information to solve problems. It involve identifying the possible use of information for solving the problem, verifying the validity and relevance of both the sources and the information itself, then collection of information can be made (David, 2016).

The components of Information system include:

Hardware: this specifically relates to computer and all of its peripherals.

Software: this relates to computer programs and all relevant documentations used to pass instruction to both hardware and other computer programs, as the case may be.

Data: these are raw facts that are processed by the system to yield information which are meaningful and useful to the user. Most times, these data sit where it is being stored until when it is fetched based on need.

Procedure: these are modalities that guide the day-to-day running of a computer system. Consider the analogy “software is to hardware what modality is to people”. Since the computer is manned by human, procedures apply to people.

People: this component include, but not limited to end users of the computer system, Computer Analysts, Network administrators etc.

Feedback: is a performance evaluation tool that serves as means of measuring past and present achievements and that which is left to be achieved.

The Information system goal includes Improved business knowledge, improved business processes and services, improved business communication and people collaboration. (Whitten & Lonnie D. Bentley, 2007)

2.5 Review of Observatory System

An Observatory is a platform that helps to oversee affairs relating to some specified indicators. It is a tool that helps to monitor, guide and manage visualization of information. An Observatory can be likened to a dashboard that contain Indicators, which are guiding questions or postulations used to tailor research. Indicators help project the research objectives. Indicators basically determines on which base; decision making can be enhanced by the activities of the environmental factors. Illustration of Indicator for an Information system on electric power is: “Number of people that uses electric power at certain peak period”, “Number of Industrial power users in a region” etc.

An Observatory is a mechanism for supervision and Guidance. Hence, in an Observatory, every indicator is expected to be given the appropriate interpretation. Any interpretation other than the one intended for an indicator, will result in wrong decisions being taken by the user of such system. The price tag for wrong economic and business decision could fall on the high side, too high to pay in some cases, as it might require bringing down the entire system (Nadine, 2014).

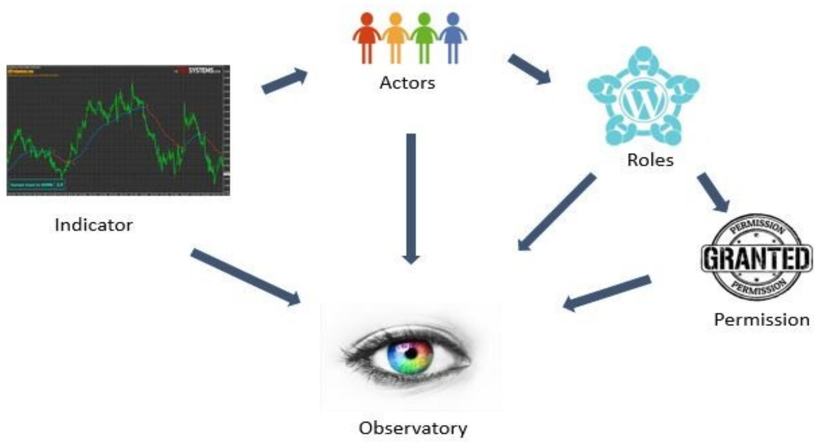

Figure 2: Features of an Observatory System

An Observatory system has actors with clearly defined roles. The actors have varying access to information from the Observatory depending on the permission granted to the actors. For any system to be effective, the security of such system has to be considered from the onset, especially at the design state. An effective Observatory is designed in such a way as to not grant access to all of its information to all users. For instance, the role of data entry cannot be granted to all users, else, the Observatory could end up being mishandled. Such role comes with privileged access to someone who is qualified to handle it. Some information are considered privileged and ought to be access based on the role of the user (authenticated user). Needful to say, in an Observatory, there is a page where all users are granted access and another page where access is granted to only the authenticated users. Also, being an authenticated user doesn't imply access to all functionalities of the Observatory. Access is a function of the role of an actor.

An Observatory is capable of projecting visualization of statistics obtained from data collected from past events, which are historical in nature, or even present events, which are products of intelligent observation made by an Observer, so as to facilitate intelligent decision making (David, 2016). The system is not always automated as it is commonly perceived, rather it is dynamic – information can be filtered to provide visualization of the required information based on need of the user at a particular point in time. The significance of an Observatory is seen in the decisions taken by policy makers which affect business and economic activities positively. The concept of transition from retrospective to predictive analysis is of relevance in the quest for improving economic and business results.

Chapter Three

Methodology

3.1 Introduction

The overall framework adopted in this project basically involve data to be collected based on the need of the system. The problem statement gave insight as to what kind of data is to be sourced for. The data collected is then verified to see if the data set contained in it that which is required to build the proposed Information system. This validation process helps to save time and cost that comes with gathering unnecessary data during system design, which could come at a very high price.

Data generally can be obtained either in Realtime, offline or online. In Realtime, the data is captured on the fly, as the event occur. The time lag here is considerably short. Sensors are required to capture data from the observed system, which are then transferred via network to a dedicated server for processing. Data collection in offline mode is a secondary means which involves getting data from pre-existing record (either in Realtime or offline). This is the mode of data collection adopted for this project. Test data were obtained from an electrical substation, which serves as input for the design of the information system. The collected data becomes online if placed on a webpage and can be accessed via internet.

Suffice to say that the adopted framework is an adaptation of a process termed as *Competitive Intelligence.*

3.2 Competitive Intelligence

Competitive Intelligence (C.I) refers to the process of gathering and analyzing publicly held data that are strategically important to a firm in its decision making process (Onu, 2013).

Competitive Intelligence has a mission of transforming data collected into relevant information by subjecting to a process of refining, which includes operations that concerns the collected data, which makes the refined data/information fit for intelligent decision making. An information is relevant (useful) if and only if it meets the need of the end user, else it's irrelevant and can be discarded. When an Information is relevant to the user, it is an exhibition of its Intelligence, which is an important attribute of a good information. Needful to say, Intelligence is referred to as a general mental capability that among other things, involve the ability to reason, plan, solve problems, think abstractly, learn quickly and learn from experience (David, 2016).

3.2.1 Competitive Intelligence Process

The effectiveness of a Competitive Intelligence process can be seen in its life cycle, that is to say, C.I is a continuous process, which should be put into action at all times for its usefulness to be experienced. Such can span long duration rather than being momentary. It is an activity carried out with patient and careful observation, documentation, analysis and reporting, which are continuous rather than spontaneous, short-term, one-time activity. Needful to say that for an organization's success, continuous application of C.I process is adopted. Hence, C.I shouldn't be considered a one-time solution to an organization's need as it is adopted as a method of exploring new opportunities and discovering new trends.

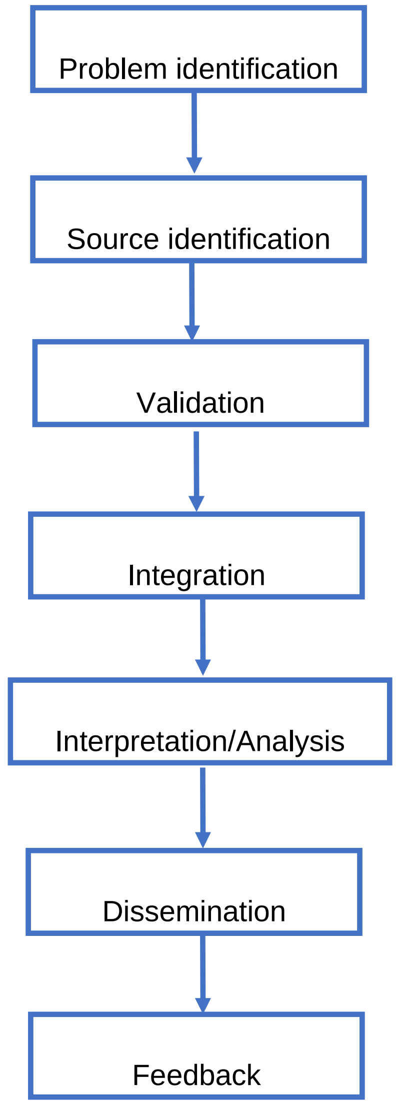

Figure 3: Block diagram of C.I process

An adaptation of the Competitive Intelligence Process was highlighted in the work of (Nadine, 2017) which was inspired by the work of (David, 2016) proposed as I-V-C model; a refined version of the traditional process of gathering and analyzing data (proposed as C-V-I model). In his model, he proposed the need for Identification of the relevance of the information to be collected in meeting the need of the problem at hand, before moving on to validate the source and information collected. This then paves way for the collection of data to be effectively carried out.

3.2.2 **Relevance of C.I process to the Application Domain**

In carrying out the task of building the Observatory system for monitoring electric power demand and delivery, the Competitive Intelligence process was adopted to aid effective gathering of data and performing required analysis that will make it relevant to the system, for its design and to the end users, for intelligent interpretation and decision making.

Having identified the problem that required the system to be designed, this gave insight as to where to source for the relevant data. Validation process then followed, which require checking of data collected to ascertained its relevance for its intended use, having validated the source of data. At this stage, the unnecessary/unwanted data is discarded. Analysis is then made on the data collected, bearing in mind the interplay of relevant indicators. The data fed into the system is disseminated by making it available and accessible online through the Observatory system.

3.3 Electric Meter

The need to monitor demand and consumption of electric energy and the potential benefits of such has led to invention of diverse monitoring devices. One of such devices used by electric power providers to measure the amount of electric energy consumed by equipment/devices that are electrically powered is the Electric Meter. Electric demand can come in the form of ratings stated by manufacturer of electrically powered devices as the power that is required by such device to be energized. When electric power is passed into a device over time (say an hour or less) then electric energy is at work. Simply put, electric energy is the electric power consumed over a duration of time. It is usually measured in kilowatt-hour, kwh. The essence of electric power is for it to be utilized by devices to carryout work. This is why electric power consumption is an issue is that is seldom avoided when the demand for electric power is being discussed. Electric power demand can also be seen in terms of the maximum use of electric power in some interval. Therefore, it not uncommon to find some electric Meters measuring demand alongside energy consumption.

In the early days, the type of electric meters in use were the mechanical types, which uses a system of gears and wheels as a technology for recording consumption of electricity (Timothy, 2017). The older types of meters referred to as Analogue meters, require the utility companies to go to location where the meters are installed to take readings of power usage, as they cannot be accessed remotely.

Modern day electric meters are digital in nature. They can be remotely accessed by the utility companies. The readings from the meter is passed down via communication lines, to a server where the utility company can process them. A kind of modern technology that allows data from meters to be transmitted as electrical signals via same powerline that supplies electric power to the house. The line is made in such a way that it can carry both power and data signals. Such technology is referred to as Powerline Carrier Communication. An advantage of this technology is reduction in cost of installing several cables separately for both power and data. A building with less cables here and there has an appealing appearance.

Since electric power is an interplay of current and voltage, a meter must always measure both quantities at all times in order to give account of power consumed. In the older days, mechanical meters that have two conductor coils that create magnetic fields are used. One of the coil is acted by the current across the conductor and the other coil is acted upon by the voltage across the conductor at a controlled rate. A thin aluminum disc is turned by the magnetic fields created by the conductor coils. Five dials record electricity consumed in the meter. They are set into motion by the movement of series of gears, moved by the aluminum disc (Timothy, 2017).

Modern day smart meters use a technology different from the mechanical meters. Current and voltages are detected by sensors, which are created to detect alternating current electric signals, they type of electricity that is oftentimes, supplied to the users by the power stations. These current and voltage values which combines over an interval of time, is then displayed by the meter in digital form.

The mechanical meters have been associated with high rate of reliability, being able to perform as at when needed. While digital meters are known for their accuracy as the sensors enable all current and voltage signals to be accounted for.

Potential benefits of smart meters include:

- Curtailing estimated bills, which is one of the numerous reasons why customers complain. Meters must be provided before billing customers (Nigeria, 2017). Customers can see what they consume and know their consumption cost as it is calculated in Realtime.
- It also helps consumers to manage their energy consumption habits thereby reducing their energy bills.

Chapter Four

Project Development

4.1 Drupal

Drupal is a free, open-source Content Management System (CMS) – a kind of online software that is used for website development. It was founded in the year 2000 by Dries Buytaert. With CMS like Drupal, non-technical people can build robust and sophisticated websites without having the right code. A Web browser is used to manage content users when the Drupal is already installed on a system. Also, with just the web interface, advance functionalities can be added with very little coding, using a large chest of building blocks that work together to create a dynamic function.

Drupal has lots of modules which help to extend and customize drupal functionality. The modules used in this project include, but not limited to: View, Administration menu, Superfish, IMCE, CKEditor, Backup and Migrate etc.

Drupal also has varities of Themes, which is a function that helps to manage the appearance of a Drupal site. Themes are part of Drupal core, but contributions are allowed by developers. The Theme used for the purpose of this project is MAYO. It is coined from the phrase “Make Your Own” and “MAYOnnaise” (“MAYO | Drupal.org,” n.d.). It is a light-weight theme, with nice colours. It supports the superfish module and also provided customizable functionalities. Just like modules, themes can also be customized to meet the need of the users (Rawtani & Chidambaram, 2009).

Drupal has lots of versions, which are products of improvements and contributions from community of users and developers. This project is implemented using Drupal 7.x.

4.1.1 Installation

The installation of Drupal requires some tools to be available to effectively manage a website. The following tools were used for the project development:

- Operating system (windows 10)
- Database engine (mySQL via phpMyAdmin)
- Php programming language
- File transfer protocol for loading Drupal files on to the webserver (net2ftp)
- Drupal core (version 7)
- Hosting site (OVH.net)

4.2 Load analysis of case study

The Injection substation used as case study consist of an incoming 33kV supply and three outgoing 11kV Feeders. These 11kV Feeders are serving G.R.A, Dutsen Kura and Hajj camp districts of Minna, Niger state, Nigeria and the area to be served consists mainly of residential buildings, small scale and agro allied industries development projects, offices and schools. Maximum demand occur in the evening when all types of equipment are in operation, also in the afternoon when commercial activities are in full gear. The basic loads have been divided into the following groups: Residential houses (both the houses occupied by indigenes and students with private accommodation); Offices, schools, hospitals and workshops; Agro-allied and small-scale industries.

For the purpose of analysis, an 11kV Feeder, to feed the surrounding communities was used as a point of reference. Each of the above groups of loads differs from another in terms of simultaneous operations.

- Residential houses: the estimated residential houses that were initially designed to be connected to the grid system on completion of the 33/11kv line was about one thousand two hundred. Each of these houses was estimated to have the following load requirement:

i. Ten (10) internal lighting points of 40 watts each.
ii. Five (5) external lighting points of 60 watts and another five of 100 watts per house.
iii. Six (6) fans per house of 120 watts each.
iv. About 200 dwelling houses would have a refrigerator and 100 would have pressing iron.
v. About 40 dwelling houses would have 2 numbers of 1.5Hp air-conditioner and 20 dwelling houses would have 2Hp air-conditioner of similar quantities.
vi. About 35 dwelling houses would have 1 number of cooker control units. 1 number immersion heater and water heater each.

4.2.1 Estimated Load for Residential Houses

Table 1: Estimated Load for Residential Houses

	APPLIANCE	RATING	RATED DEMAND IN KW	NO OF HOUSES	ESTIMATED LOAD	TOTAL ESTIMATED LOAD IN KW
1.	LAMP	40W	0.04	1200	0.04*1200*10	480
		60W	0.06	150	0.06*150*5	45
		100W	0.10	120	0.10*120*5	60
		250W	0.25	70	0.25*70*1	17.5
2.	IRON	750W	0.75	560	0.75*560*1	420
3.	FAN	0.3HP	0.22	650	0.22*650*6	1056
		0.08HP	0.06	200	0.06*200*1	12
4.	KETTLE	2000W	2.0	45	2.0*45*1	90
		3500W	3.5	36	3.5*36*1	126
5.	WATER HEATER	1200W	1.2	70	1.2*70*1	84
		2500W	2.5	30	2.5*30*1	75
6.	COOKER (4 PLATE WITH OVEN)	8000W	8	35	8*35*1	280
		10500W	10.5	7	10.5*7*1	73.5
7.	SINGLE PLATE COOKER	1800W	1.8	80	1.8*80*1	144
8.	TOASTER	1000W	1.0	15	1.0*15*1	15
9.	AIR CONDITIONER	1.5HP	1.1	40	1.1*40*2	44
		2HP	1.5	20	1.5*20*2	60
10.	REFRIGERATOR	0.2HP	0.15	40	0.15*40*1	6
		0.25HP	0.19	36	0.19*36*1	6.84
		0.3HP	0.22	15	0.22*15*1	3.3
11.	TRANSISTOR RADIO	5W	0.005	23	0.005*23*1	0.115
12.	RADIOGRAM/ STEREO SYSTEM	100W	0.10	55	0.10*55*1	5.5
13.	T.V	300W	0.3	650	0.3*650*1	195
14.	VACUUM CLEANER	700W	0.7	60	0.7*60*1	42
		900W	0.9	24	0.9*24*1	21.6
15.	WASHING MACHINE	600W	0.6	50	0.6*50*1	300

Total load = 3667.355kW

a. Hospitals, schools and Workshops (and other offices): These include school, hostels: estimated power requirement in a day for hospitals, offices and small workshops, amount to a total load of 850kw.

b. Agro-Allied and small Industries: These shall be in addition to internal and security lighting points and electric motors for three fuel pumps include the following from which the total estimate load should be derived.

- ten numbers of cassava grinding/process mill
- four sawmills
- petrol station with about three pumps
- one rice processing mill
- ten bore holes

4.2.2 Estimated Load for Agro-Allied and Small Scale Industries

Table 2: Estimated Load for Agro-Allied and Small-Scale Industries

Items No	Item description	Rating	Total kw
i	60 nos. lighting points	40W	2.4
ii	18 nos. security Lighting Panel	250W	3.75
Iii	3 nos. fuel pump Electric motor	1.5HP	3.357
Iv	10 nos. Electric motor for cassava grinding mill	5HP	37.30
V	4 saw mill machines	2.5kW	10
vi	1 no rice processing mill Electric motor	7.5HP	5.595
vii	10 boreholes electric motor	2HP	14.92
viii	4 no of electric motors for grinding purpose	3kW	12

Total load for Agro-Allied Industries and Small-scale industries = 89.322kW

4.3 Models

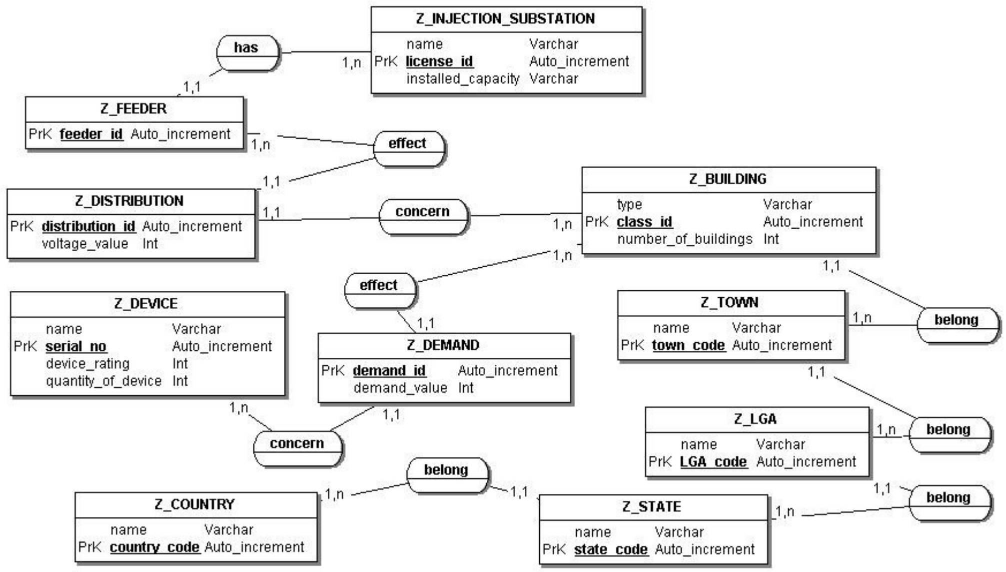

Figure 4: Entity-Relation Model

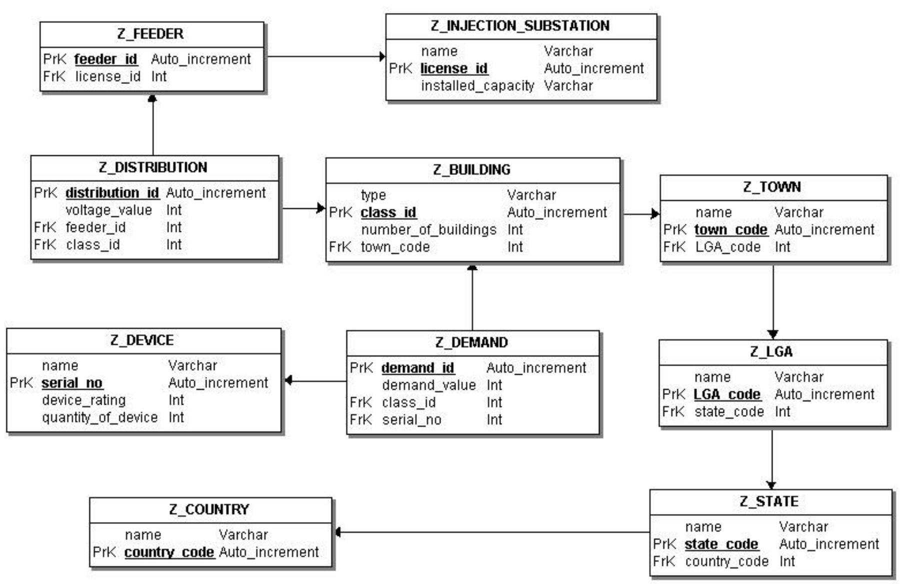

Figure 5: Relational Model

4.3.1 Analysis of the Entity-Relation model

An Injection Substation has minimum of 1, maximum of many Feeders; a Feeder belongs to minimum of 1, maximum of 1 Injection substation.

A Feeder effect minimum of 1, maximum of many Distribution; an act of distribution is effected by minimum of 1, maximum of 1 Feeder.

An act of distribution concerns minimum of 1, maximum of 1 building; a building is concerned with minimum of 1, maximum of many distributions.

A building effects minimum of 1, maximum of many demands; an act of demand is effected by minimum of 1, maximum of 1 building.

An act of demand concerns minimum of 1, maximum of 1 device; a device is concerned with minimum of 1, maximum of many acts of demand.

A building belongs to minimum of 1, maximum of 1 Town; a Town is contained of minimum of 1, maximum of many buildings.

A Town belongs to minimum of 1, maximum of many Local Government Area (LGA); a Local Government Area is contained of minimum of 1, maximum of many Towns.

A Local Government Area belongs to minimum of 1, maximum of 1 State; a State is contained of minimum of 1, maximum of many Local Government Areas.

A State belongs to minimum of 1, maximum of 1 Country; a Country is contained of minimum of 1, maximum of many States.

The following can be deduced from the Observatory with respect to the test data:

- Power demand of Residential Users
- Power demand of Agro-allied and Small-scale industries
- Power demand of Users with Refrigerator
- Power demand of Users with Air condition
- Power demand of Users with Lamps
- Power demand of Users with Vacuum Cleaners
- Power demand for Users with Lighting points
- Power demand for Users with Electric Motors

4.4 **Implementation**

The Information System was developed using Drupal CMS, version 7; with some other tools mentioned in the previous section of this project. Screenshots from the site are shown below:

The User Login page is shown below

Figure 6: User Login page

The Home page is shown below:

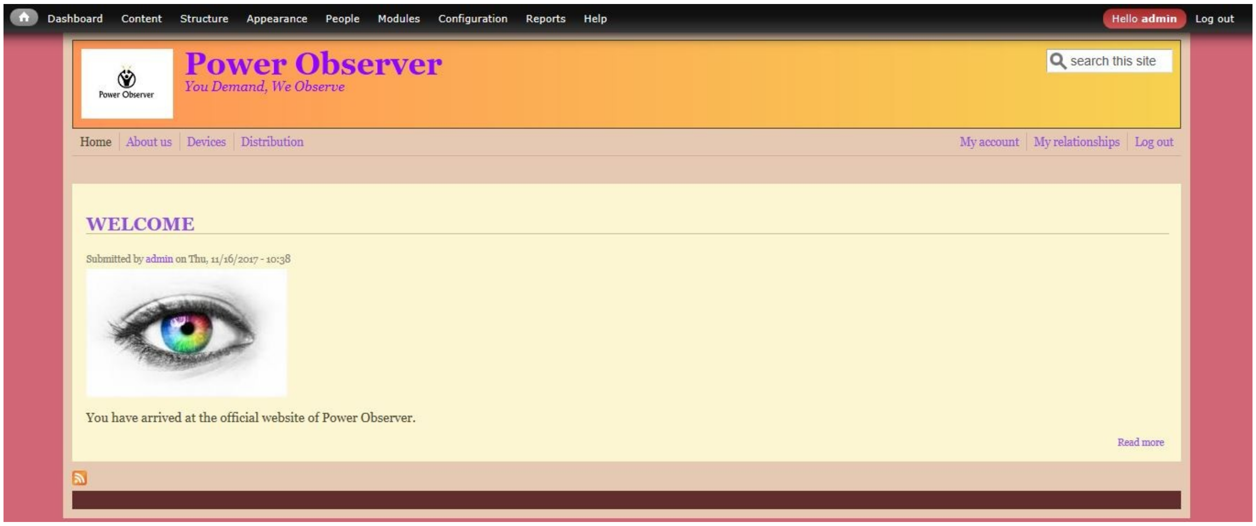

Figure 7: Home page

The About us page is displayed below:

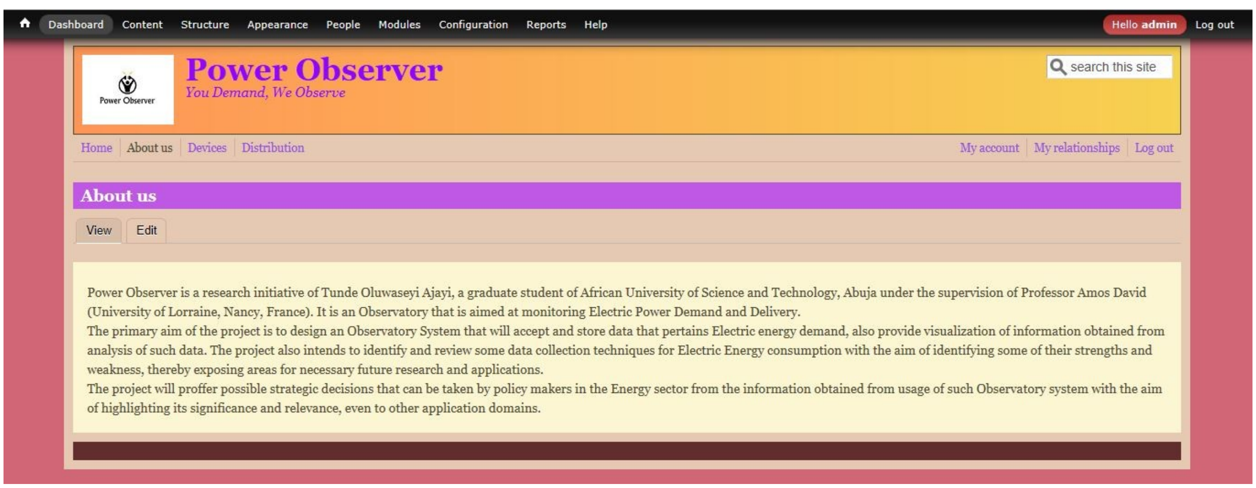

Figure 8: About us page

The Devices page consisting of some demands of appliances is displayed below:

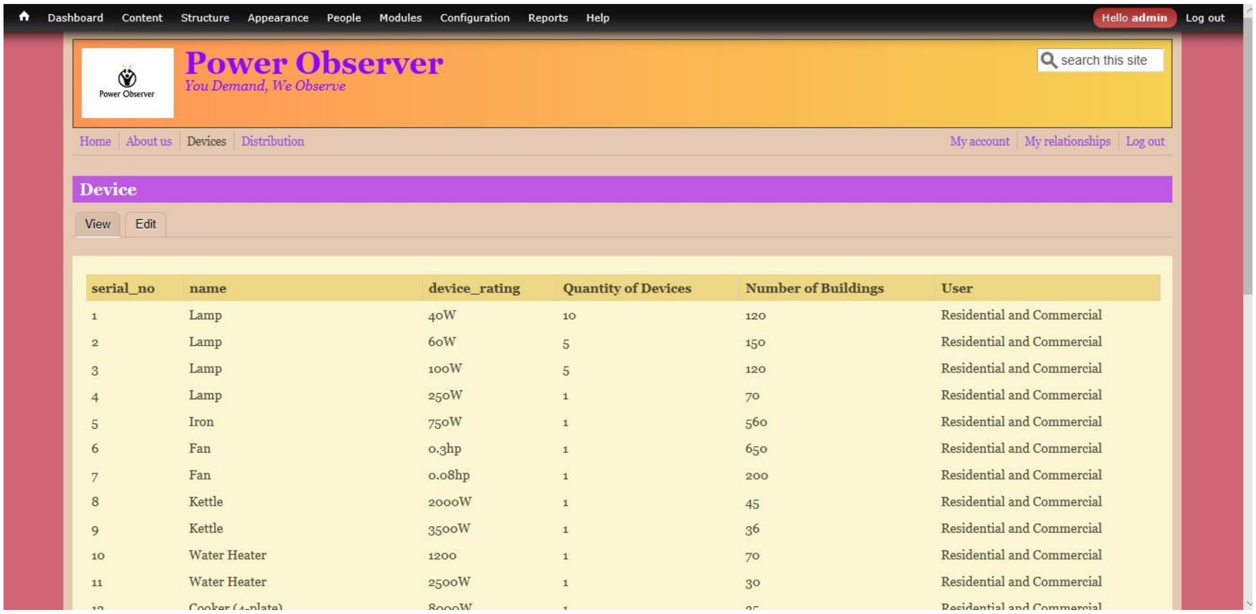

Figure 9: Device page

The above are some implemented pages for the Information system. The site is still a work-in-progress, some functions are yet to be implemented due to time constraint in the documentation and implementation.

Chapter Five

Conclusion and Future Research Areas

5.1 Conclusion

This report is a documentation of a project which required developing an Information system (Observatory) that makes available, online statistics of Electric Power Demand. The statistics provided will serve as a decision-making tool for policy makers in the relevant sector to plan optimal strategies for better delivery of Electric power, especially in the area of provision of Electrical Infrastructure. The development of the Information System was achieved using Drupal Content Management System.

5.2 Future Research Areas

In carrying out the project, some scientific and technical issues encountered made worth considering, the idea of taking up the project development a step further. The Observatory system is an online system; data were collected from pre-existing record to uploaded to the site. In future, research into Realtime techniques of collecting data without having to manually collect data is worth considering.

For future work, research would look at techniques of handling situations where modification is to be made to an Information system (at the barest minimum cost) after design of models have been made without necessarily dropping the entire database.

Another area worth considering is for future research is the adaptation of the concept learned in this project to other application domains, bearing in mind the underlying principles imbibed in the course of handling this project. As practical illustration of this future research area, I propose an **Observatory System for Effective Monitoring of**

Smart Electricity Grid. A research area as this would require a synergy of Information System, Electrical Engineering and Computer science disciplines.

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