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Factors Affecting Electric Power Distribution in Sokoto State -Nigeria

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ABSTRACT
Efficient and uninterrupted electrical power distribution plays an important role in the quality of modern daily life as the role of electricity cannot be over emphasized. It is obvious that the efficiency and performance of electrical power distribution systems have significant impact on distributionof electrical power. In Sokoto state Nigeria, access to reliable and stable electric power supply is a major challenge for all the twenty-three (23) local government areas of the state including the state capital. Although, all the local government areas have distribution networks systems, but due to vandalization, use of sub-standard materials and lake of maintenance caused nine (9) local government areas out of electric power supply, while fourteen (14) local government areas do not have adequate electric power supply due to lake of distribution system upgrade to meet up the demand of electric power supply.

A prominent state in Nigeria experiencing poverty of electrical power supply can be said to be a situation where its citizens lacks their basic needs such as lighting, security, cooking etc. In this situation, a large number of people in the state are negatively affected by lack /low consumption of electric power, this necessitates many individuals in the state to use dirty polluting and time-consuming fuel in order to meet their basic needs, for example cooking. The research will pin points the root cause of the problems affecting electric power distribution in Sokoto state and needs for the government to review and implement policies on distribution of electric power.
Keywords: *Electric, Power, Distribution, Lightings, Cooking and poverty.*
Key words: *Sub-standard, Electrical installation, Efficient, Safe, Loos, Offices, Factories, Schools, Hospitals.*

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I. INTRODUCTION

Electric power is the certain amount of electrical energy used in a certain amount of time. Energy is the ability to do work while power is the rate at which energy is used. The part of electric power system which distributes the power to consumer/consumers is known as distribution system.Development of any nation depend upon its technology, the technological machineries use electric power to operate, it is therefore necessary to provide efficient, reliable and safer Electric power distribution systems. This will no doubt improve medical care, agriculture, education, economy and security.

The electrical energy produced at the power station is transmitted at very high voltages using 3-phase, 3-wire system to step-down sub-station for distribution. The distribution system consists of two parts viz. Primary distribution and secondary distribution. The primary distribution circuit is 3-phase 3, wire and operate at 33 or 11KV (Kilo-volt). It delivers power to the secondary distribution circuit through distribution transformers situated near consumer's localities.

A typical distribution system consists of a step-down transformer (example 33/11KV) feeding number of lines with varying length from a few hundred meters to several kilometers. Several three -phase step down transformers, example11KV/0.415KV are spaced along the feeders and from these, three- phase four wire (0.415KV) and single phase two wire(230V) networks are supplied to houses and similar loads.

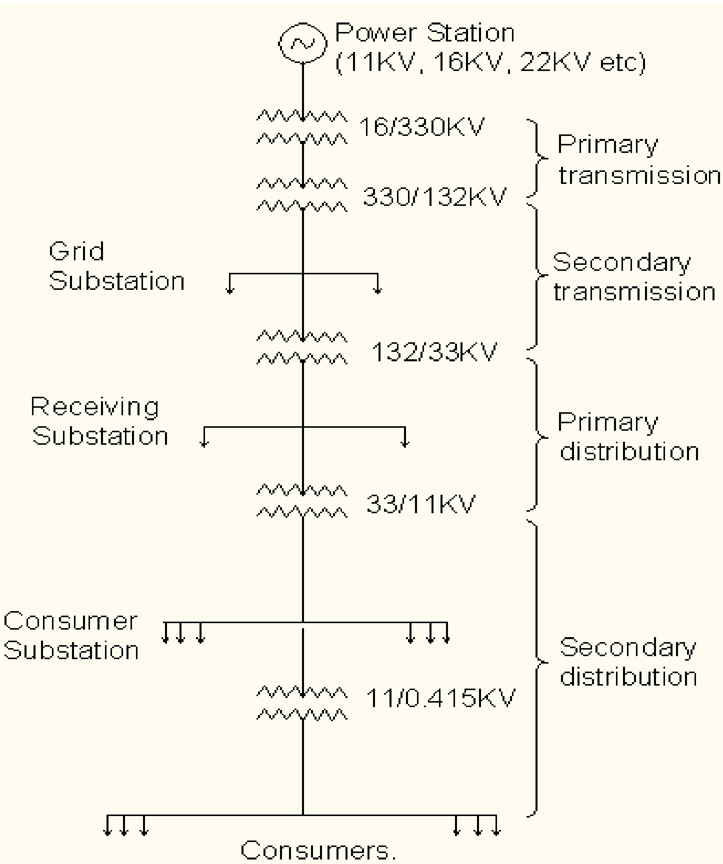


Figure 1.Typical electric supply system.

Electric power distribution system is made up of distribution lines and sub-station. Distribution lines are aluminum conductors terminated with suitable insulators where necessary and supported by reinforced concrete pole of 28feet or 32feet height depending on the voltage level. Distribution Sub-station provide essential electrical link between systems operating at different voltages. It is use for switching, voltage transformation and control of the system voltage. All these can be achieved through the use of sub-station components. The components are as follows:

-Transformer
-Circuit breaker
-Bus
-Isolators
-Battery and charger
-Instrument transformers

-Transformers: Transformers are used in distribution stations to step down the voltage base on the electrical load requirement. This is done through magnetic induction in the winding for the transformer. Transformer provide efficient, reliable static means of changing voltage from one level to another.

The basic construction of transformer would include an iron core with insulated windings around the core.

Bushings are used to permit power to enter and exit. These bushings will be constructed of either porcelain or epoxy. Current transformers are usually mounted around the bushings for protective relaying or metering. Lightening arrestors are installed to protect the transformer's insulation system by limiting the magnitude of lightening voltages that may be present during storms. The lightening arrestors are generally placed as close to the transformer as possible.

The size of winding and the type of cooling system of the transformer determine the current rating of the transformer. The product of voltage rating in volts (KV) and the current rating in amps (A) gives the power rating of the transformer in kilovolt-amperes (KVA).

-Circuit breakers: Circuit breakers are installed in distribution sub-station to protect against undesirable (fault) situations that can occur in a power system. Many of these problems create excessive amount of current to flow within the power system. High current in turn creates high temperature which if left unattended, can cause severe damage to electrical equipment. Also, if excessive current is allowed to follow for more than a few milliseconds, service may be interrupted in other part of the power system. Faulty circuit must be disconnected from the power system automatically and with great speed. Circuit breakers provides the means for disconnecting circuits carrying short-circuit current or overloads.

-Bus: is arrangement of conductors where incoming and outgoing conductors are connected. The incoming power supply conductors for distribution are connected to the Bus, likewise the outgoing conductors. In a distribution sub-station, Bus can be either outdoor or indoor. Outdoor is generally supported on grounded steel columns that use insulators to support the bus work. Outdoor bus is often constructed out of round aluminum section that are bolted together and terminated with special bus connectors.

-Isolators: are devices for disconnecting/connecting electrical supply in distribution sub-station. They should be installed before and after a breaker, for maintenance work to be carried out on the breaker both isolators should be disconnected.

-Battery and charger: Storage batteries in sub-stations supplies the necessary energy to operate circuit breakers and other equipment within sub-station. Batteries make it possible to operate during period of system disturbance or outage, such as lightning storms. The batteries are design to be connected in bank to produce the necessary DC voltage required by the equipment. Batteries are sometimes referred to as the “heart” of the control system, because without them, breakers would not be able to trip open when call upon. Without dependable batteries protective relaying is rendered useless

-Instrument transformers: are devices responsible for indicating and sending signal about the station power system parameter. The devices are relays, current transformers, voltage transformers and contactor.

II. Literature Review

Electricity access is low in Nigeria which is the largest economy in Africa in terms of GDP and population (Emodi and Yusuf, 2015). At present, only 10% of rural households and 40% of the country's total population have access to electricity (Oseni, 2012). Among those who have access, a comparable number receive electricity services that are below the standards of quantity and reliability expected of an efficiently performing sector. The situation is significantly different at different geopolitical zones.

A report released by the World Bank and some foreign organizations has shown Nigeria taking the ignominious position of the second worst country with high electricity access deficit. The report states that 82.4 million Nigerians lack access to electricity. In an assessment of the worst 20 countries in the world, Nigeria came second to India with a population of 306.2 million people with lack of access to electricity. Unfortunately, while India, China, Indonesia, Pakistan, Bangladesh, Brazil, Philippines are moving very fast to resolve the challenge ahead of the Sustainable Energy for all by 2030, Nigeria is lagging with an annual increase in the access to electricity at the rate of 1.8 percent (Sustainable Energy for All Initiative, 2012).

Electricity access is more than just a connection to a distribution network; it requires that electricity is provided adequately as demanded and in a reliable, affordable manner. The provision of adequate and reliable electricity service on demand requires a balanced, planned expansion of generation capacity and transmission and distribution (T&D) for delivering electricity securely and efficiently, based on the location of generation plants and load centers, and coordinating with off-grid options where feasible. Policies and regulation are needed to achieve this, both to facilitate the large capital investments needed to bridge the access gap and to ensure that electricity services are financially viable and affordable for all, especially the poor (Heider et al., 2015).

According to South Africa’s electricity supply company - Eskom, electricity distribution in various countries which is usually carried out by their respective electricity distribution industry plays a very important role to those supplying and consuming it (Eskom, 2015). (Abdelhay & Malik, 2011) describes electricity distribution as an important stage in the three-stage delivery of electric power which also includes generation and transmission. With the world population steadily increasing from 6.8billion people in 2011 to 7.4 billion in

2015, Ross (2015) recognizes that, challenges faced by EDI's in the distribution of electricity are bound to multiply. This is because these challenges which include generally poor infrastructure, wear out of distribution grids and climate change, are compounded by increase in the demand for electricity. Other authors like (Bouttes, Dasaa & Crassons, 2011) support Ross' view by identifying 3 main global challenges faced by the delivery of electric power – increase urbanization, the change in climatic conditions and the increase of demand in power. The problems faced with electricity distribution around the world, even though common, occur at different intensities in different countries.

In places like the United Kingdom, for example, there is more concern about future electricity distribution. (Watson, McDonald & Ferguson, 2001) says that the method used for distribution network design now that is based on the reinforcement network will be outdated for network designs in the future as the rely heavily on reinforcing network practices. They view this problem not only as a mechanical problem but also a managerial challenge as the design makes less severe the challenges of electricity distribution and at the same time hindering the ease of taking advantage of the opportunities. In India, managerial reforms and governance have included the 2 unbundling of their electricity distribution system such that there are both economic incentives and disincentives and more private players in distribution. A critical assessment by the country's electricity planning commission revealed that this reform has weaknesses in terms of performance and affordability of electricity. While realizing that it is good for free and fair c According to the Energy Poverty Action Initiative of the World Economic Forum (IEA, 2007), "Access to energy is fundamental to improve the quality of life and is a key imperative for economic development."

Poor access to energy in Sokoto State obviously translates into increased poverty, poor economic performance, limited employment opportunity and complicated prospects for institutional development. The high growth rate of the population is an indication that the country's energy demand will continue to rise, similar to how the increase in global population and industrial transformation of the 20th century tremendously increased energy demand (Mohammeda, 2013).

Lack of electricity has forced about 62% of Nigerians to rely on wood fuel for their entire energy needs resulting in massive deforestation in the country (Babanyara and Saleh, 2010; Eleri et al, 2012; Zubairu et al., 2015).

A case study by the World Health Organization in 2013, the death caused by smoke inhalation from fire wood used by women reached 98,000 (Emodi and Boo, 2015).

Statement of problems

Fear is mounting that, the ingredient (electric power supply) for good standard of living is very limited or even totally absent in some local government areas of Sokoto state. Lack of electric power supply will tie down health, agricultural, educational economic and security sectors, as such the issue of technological development will not even arise due to poor or inadequate electrical power supply. This will eventually result in lack of medical care, hunger, illiteracy, poverty, these causes social crisis.

Distribution system planning

System planning is essential to assure that the growing demand for electricity can be satisfied by distribution system in addition to the existing demand. Distribution system planning starts at the consumer level, the demand type, load factor and other consumer loads characteristics dictates the type of distribution system required

Once the consumer loads are determine, they are grouped for service from secondary lines connected to distribution transformers that steps down from primary voltage. The distribution transformer loads are then combined to determine the demands on the primary distribution system. The primary distribution system loads are then assigned to substations that step down from transmission voltage. The distribution system loads, in turn, determine the size and location or siting of the substations as well as the routing and capacity of the associated transmission lines.

Load Forecast

Load growth of the geographical area served by a utility company is the most important factor influencing the expansion of the distribution system. Therefore, forecasting of load increases and system reaction to these increases tote planning process. There are two common time scales of importance to load forecasting: long range, with time horizon on the order of 15 or 20 years away, and short range, with time horizons of up to 5 years. Ideally these forecast would predict future loads in detail, extending even to the individual customer level.

For example, if an electrical load enumeration conducted in an area shows that the present electrical load is 300KW, to provide load forecast for fifteen years using 15% increment on consumption, from year two to year five; 15% increment in consumption. From year six to year ten 10% increment in consumption. From year 11to year Fifteen; 5% increment in consumption. The load forecast will be:

Year one load is$300KW$, using 15% increment in consumption.
Therefore, 15% increment will be:

$$= \frac{300KW}{100} \times 15\% = 45KW$$

Year second load will be: first year load plus 15% increment

$$= 300W + 45KW = 345KW$$

Year three load will be:second year load plus 15% increment

$$= \frac{345KW}{100} \times 15\% = 51.8KW$$

$$= 345 + 51.8KW = 396.8KW$$

Year fourload will be:third year load plus 15% increment

$$= \frac{396KW}{100} \times 15\% = 59.5KW$$

$$= 396 + 59.5KW = 455.5KW$$

Fear fiveload will be:fourth year load plus 15% increment

$$= \frac{455.5KW}{100} \times 15\% = 68.3KW$$

$$= 455.5 + 68.3KW = 523.8KW$$

Year six load will be:fifth year load plus 15% increment of the fifth year plus 10% of the sixth year i.e. 25% increment

$$= \frac{523.8KW}{100} \times 15\% = 78.6KW$$

$$= 523.8KW + 78.6KW = 602.4KW$$

Therefore, 10% increment will be:

$$= \frac{602.4KW}{100} \times 10\% = 60.2KW$$

yearsix load will be: $523.8KW + 78.6KW + 60.2KW = 662.6KW$

Year sevenload will be: sixth year load plus 10% increment

$$= \frac{662.6KW}{100} \times 10\% = 66.3KW$$

$$= 662.6KW + 66.3KW = 728.9KW$$

Yeareightload will be: seventh year load plus 10% increment

$$= \frac{728.9KW}{100} \times 10\% = 72.9KW$$

$$= 728.9KW + 72.9KW = 801.8KW$$

Year nine load will be:eighth year load plus 10% increment

$$= \frac{801.8KW}{100} \times 10\% = 80.2KW$$

$$= 801.8KW + 80.2KW = 882KW$$

Year tenload will be
year eight load plus 10% increment

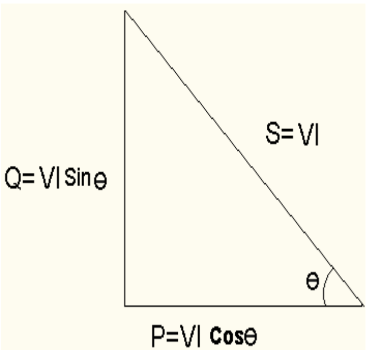
$$= \frac{882KW}{100} \times 10\% = 88.2KW$$

$$= 882KW + 88.2KW = 970.2KW$$

Electrical power triangle

Electrical power triangle is triangles that consist of three type of electrical powers. Being it triangle the three powers are shared among the three side of the triangle, therefore Pythagoras theorem i.e. can be applied to find any one of the three electrical power provided any of the two powers are given.

True/real power (P): for rating of electrical load measured in watt, kilo-watt, and mega-watt.
Apparent power (S): for rating of electrical generators, motors etc. measured in volt-ampere, Kilo-volt-ampere, mega-volt-ampere.
Reactive power (Q): for rating of electrical power that goes back to the sourcemeasured in Volt-ampere, kilo-volt-ampere, mega-volt-ampere.



$S^2 = P^2 + Q^2$

Figure 2.Power triangle

$S = \sqrt{P^2 + Q^2}$

$$\square = \text{power factor} = \frac{True\ power}{Apparent\ power}$$

For example, using true power of 970.2KW as given on year ten of the load forecast above and 0.8 as power factor.

$$\square = \text{power factor} = \frac{True\ power}{Apparent\ power}$$

$$0.8 = \frac{970.02}{Apparent\ power}$$

$$\text{Apparent power} = \frac{970.02}{0.8} = 1{,}212.5 \text{ KVA (Kilo-Volt Ampere).}$$

There is no 1,212.5 KVA transformers available in the market on less on special request. Therefore two (2) numbers 500 KVA and one (1) number 200KVA transformers should be used
For 970.2KW for about ten (10) years as forecasted.

If the 500KVA transformer is used as specified above, also the line supplying the transformer

Current, $I_S = \frac{P}{\sqrt{3}\, V\, COS\theta} = \frac{500{,}000}{1.732 \times 415 \times 0.8}$ =869.5A

Substation Expansion

The need for substation expansion usually arises after executingload forecasted period, at this period up grading of the substation components and lines is necessary for meeting up with load growth.

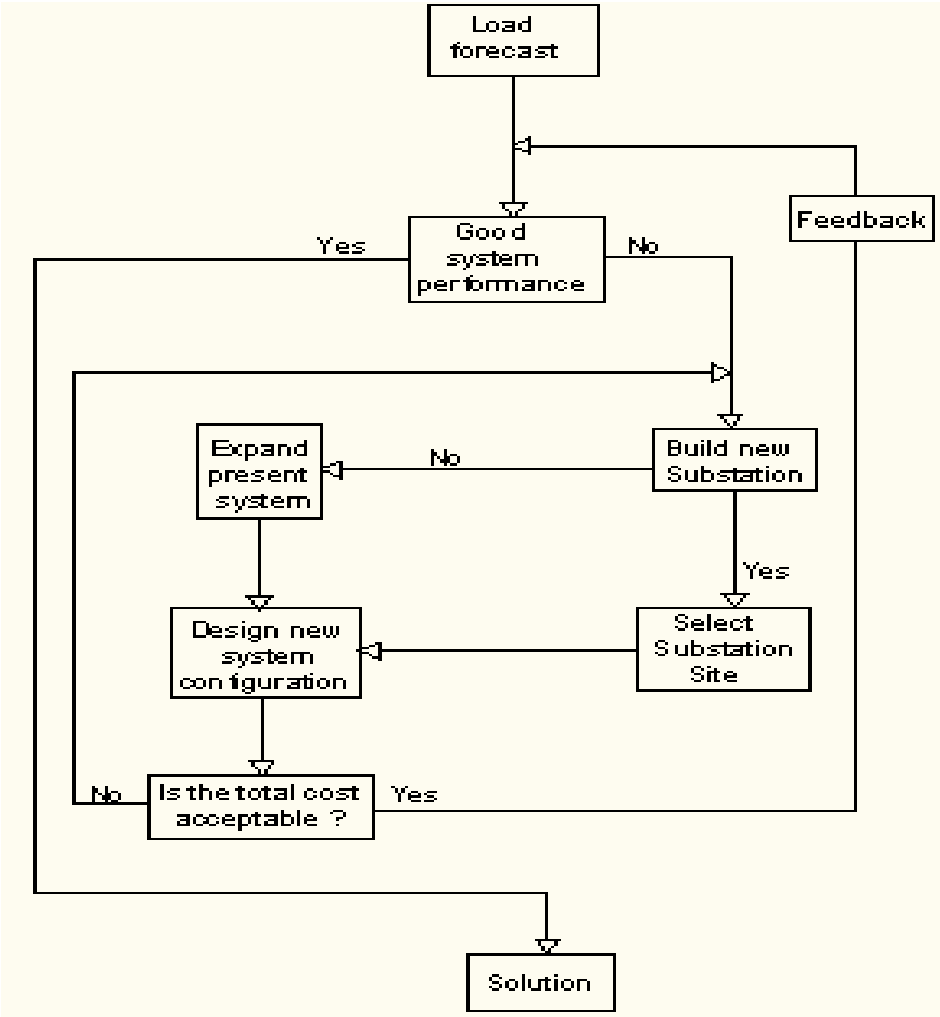


Figure 3.Substation Expansion flow chat.

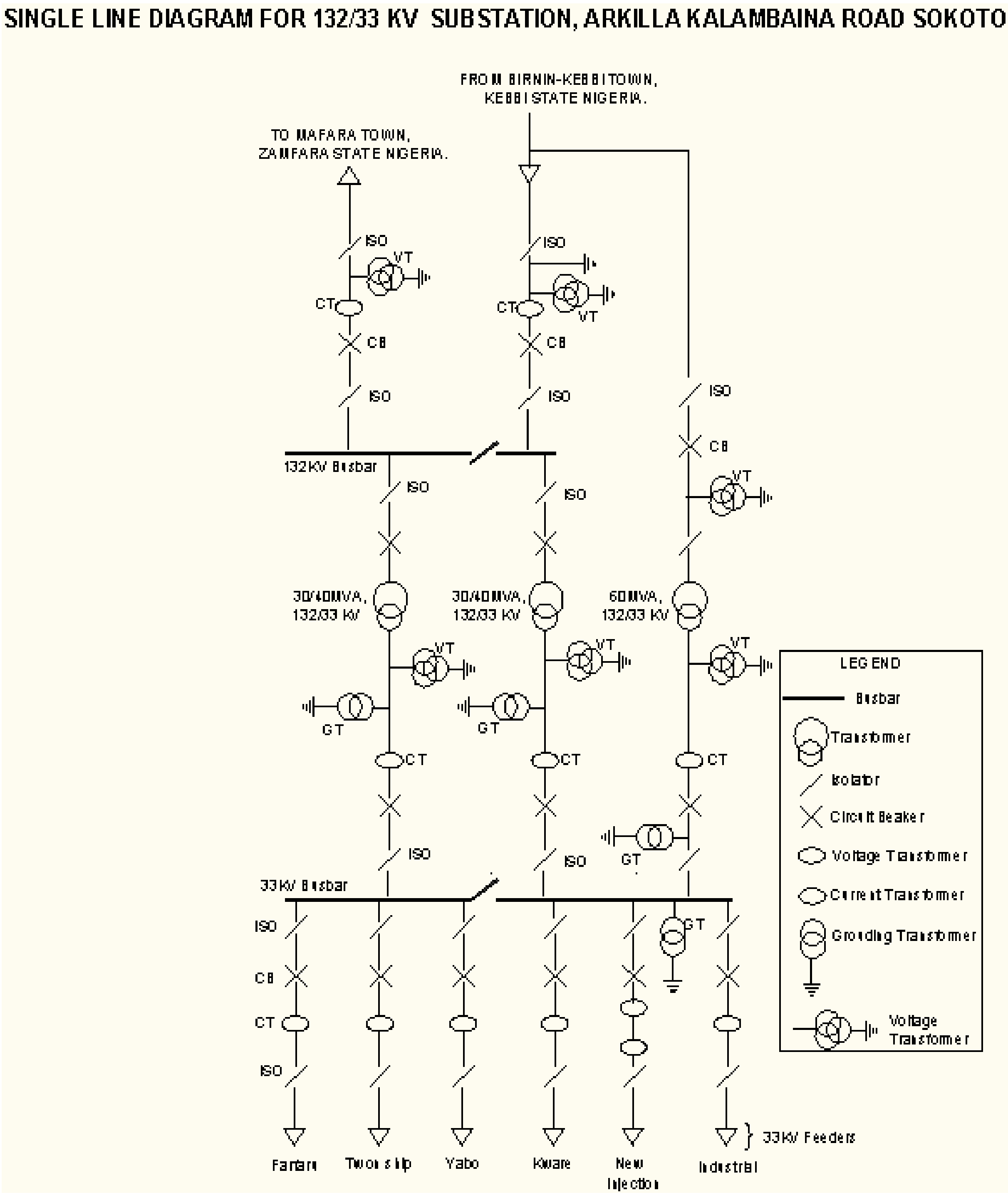


Figure 4.Single line diagram for 132/33KV SubstationSokoto.

The132/33KV stations has the capacity to accommodate up to 96MW because the three transformers in the station are 30, 30 and 60MVA as shown in figure 4.
30MVA +30MVA +60MVA= 120MVA, applying power factor of 0.8, the total load which can be carried by the three transformers will be; 120MVA/power factor = 96MW.

Expected load	Peak load	Supply load
100MW	35MW	30MW

Table1. Electrical load in Sokoto state.

Therefore thefactors affecting electric power distribution in Sokoto state are within the distributionlevel since the transmission system has the capacity to accommodate up to 100MW.
The factors affecting the distribution systems are numerous ranging fromlack of load forecast during design/installation, lack maintenance of the existing distribution systems, lack of upgrade due to load growth, and vandalization. Below are pictures of some problems within the distribution systems.


Figure5. Broken dual pole in service. Figure 6. Under sized 415V Bus bar in service using wrong size of fuse in addition to birds nest behind the left unit at the top.


Figure 7.Exposed and unfenced 415V Bus bar in service. Figure8. 4I5V up riser cable insulation break down due to partial contact/over load

Figure 9.Unprotected 11/0.415KV sub station.

Figure 10. Exposed underground cables

Figure 11.Saged 415V line in service

Figure 12.Low tension pole along with line Inclined on high tension pole

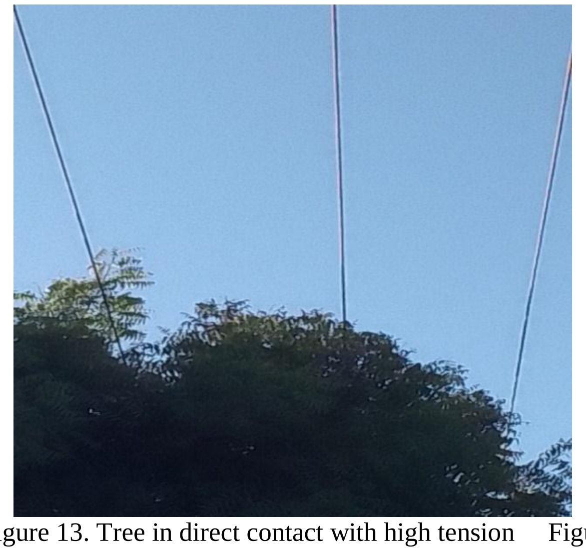


Figure 13. Tree in direct contact with high tension Line.

Figure 14.Low tension pole along with line Inclined at 45^0 on a tree around a residential Building.

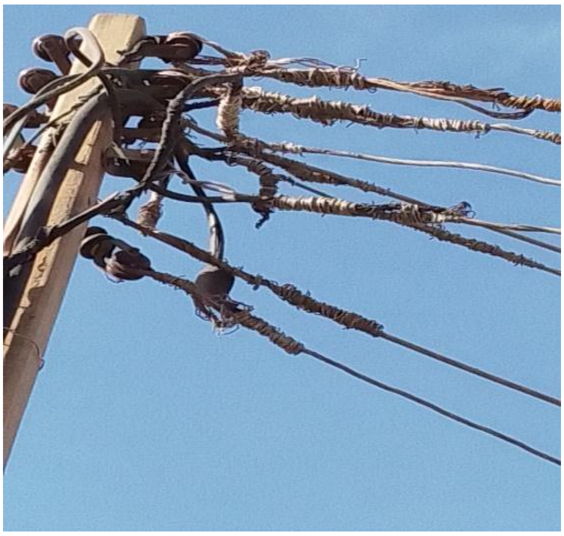


Figure 15. Substandard cable jointing due lack of using line tap and proper cable arrangemt.

Figure 16. Undersized 415V line conductor and Wooden pole.

Figure17. Vandalized 415volt substation.

18.Substandard415volt bus bar

Figure 19. Substandard fuse elementused in 415volt busbar

The findings shows that; most of the factors affecting electrical power distribution are within the secondary distribution level.

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