Addis Ababa University

College of Business and Economics

Department of Management

Research Project for Partial Fulfillment of EMBA

Topic: "Assessment of Power Interruptions in Addis Ababa".

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Assessment of Power Interruptions in Addis Ababa

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ABSTRACT

This research project is done for the primary purpose of assessing electric power interruptions in Addis Ababa. Power interruption becomes a serious problem in the city in everywhere. The number of outages is very high and it takes long time for service restoration. Due to this every aspects of business and non business activities and day to day lives of the city residents are negatively affected and highly complained with this problem. Moreover the power interruptions cause wastage of power or power losses significantly. The objective of this research project is identifying the root causes of power interruption and identifying and forwarding the appropriate remedies for the identified problems. For this end primary and secondary data are collected, a subsequent four year power interruptions secondary data are collected from the service provider.

A primary data is collected through open ended and close ended questionnaires, interviews and observations. Questioner is developed for electric power customers, for the service provider distribution and transmission operation staffs. Representative sample is determined based on random sampling method at 95% confidence level and at 5% margin of error. As per this 384 samples is determined out of 523,944 electric power customers and 184 sample employees from a total 362 employees.

The analysis is done based on descriptive research analysis by using both qualitative and quantitative methods. Problems identifications are also done through SWOT analysis and root cause analysis. Root cause identifications are done through problem tree analysis. The research analysis find outs that power interruptions, power drops and poor customer services are major problems in electric power service. The root causes of the existing power interruptions are infrastructure capacity limitations, poor infrastructure & design, infrastructure management problem, poor planning & forecasting, exposure of infrastructures for theft & accidents, natural accident and water shortages. The company can minimize the power interruption problems by upgrading power supply infrastructure capacity, improving power infrastructure & design, improving infrastructure management practices, developing effective planning & forecasting practices: establishing preventive maintenance systems, applying power infrastructure rehabilitations works, supplying adequate and standard quality inputs, minimizing operational interruptions, developing infrastructure capacities, improving human resource management Practices and by making further studies.

Electric power interruption is power outages and blackouts due to various reasons. Frequency of power interruption indicates the rate of occurrence or the number of repetition of the power interruptions in the grid systems. Whereas interruption duration indicates the length of time the power interruption continues or exists in the power grid systems.

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CHAPTER ONE: INTRODUCTION

1.1 Overview of the Company

The Ethiopian Electric Light and power Authority (EELPA), which was established in 1956, after having undergone restructuring had been reorganized as Ethiopian Electric Power Corporation (EEPCo) .The Ethiopian Electric Power Corporation (EEPCo) as public electric utility enterprise is named in 1997 for indefinite duration by regulation No. 18/1997.

Now as per the new restructuring of Ethiopian Electric Power Corporation the corporation is split in to two companies namely Ethiopian Electric Utility (EEU) and Ethiopian Electric Power (EEP). The EEP is formed by Council of Minister's Regulation No. 302/2013 dated 27th of December, 2013. EEP is responsible for design and development of electric generation, transmission, and substations and all operational and maintenance tasks. And EEU is established by Council's of Minister's Regulation No. 303/2013 dated 27th of December 2013 is responsible for administration of electric power distribution networks, purchase bulk electric power and sell energy to customer.

The company installed generation capacities is around 2200 MW from hydro, wind, geothermal and diesel power plants. It uses a transmitting lines operating at 400kV, 232kV, 132kV 66kV, 45kv, 33kv and 15kv spread across the country. Presently, 138 substations; more than 687km of 400 kV and 3,550 km of 230 kV lines constitute the HV transmission system; 4,038km of 132kV; 2,234 km of 66 kV and 476 km of 45 kV lines constitute the sub-transmission system are used to supply electrical power to customers. The 33 kV and 15 kV primary voltages are used for electric power distribution.

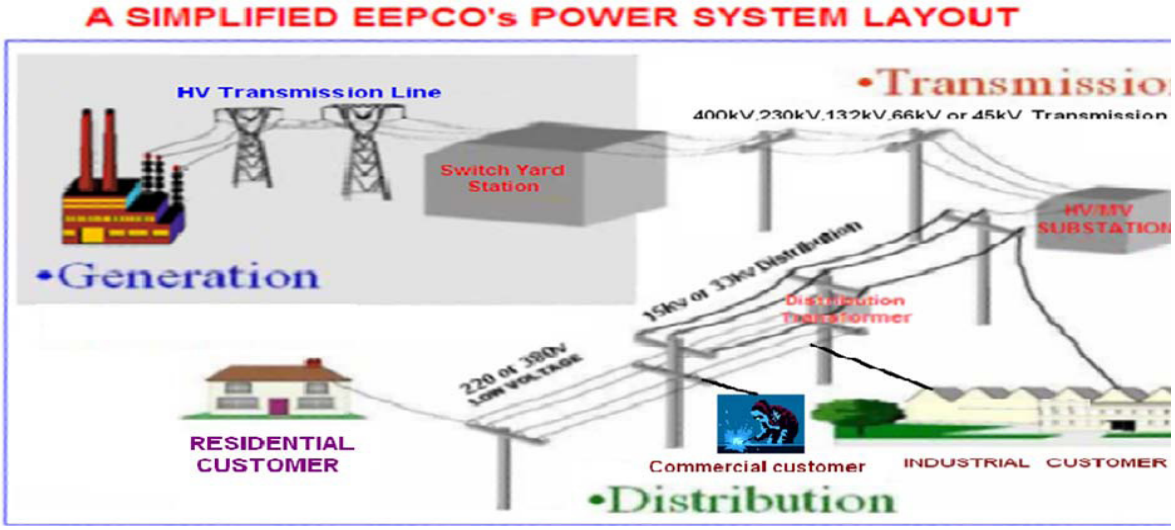
The envision in the sector is improve access to modern, safe and sustainable energy services, increase power production from renewable such as biogas, micro-to-mini-hydro, geothermal, solar and wind , improve energy efficiency in terms of generation, transmission, distribution and consumption. The sector aims at a five-fold increase in hydroelectric power generating capacity, and doubling the number of consumers with access to electricity. (National Indicative Program for Ethiopia 2014 to 2020, p15-17)

The electric energy supply systems are the interconnected system (ICS) and the self contained system (SCS).The main energy source of the interconnected system (ICS) is hydro power plant and wind farms and for SCS its main source are mini- hydro plants and diesel power Generators allocated in various areas of the country.

The supplied Electric power is generated from hydro, wind, geothermal and fuel sources in scattered and remote geographical location of the country. And then transmitted to the nearby step up transformers around the generation site for upgrading and then the upgraded high kilo volt power is transmitted through transmission line to substations. The electric power from substation distributed through the distribution network to industrial, commercial and domestics' end users (see the power system layout in figure 1.1).

Electric power supply operation systems are continuous operations systems that need a careful design and the most efficient operation management systems to assure the smooth function of the systems. But in the case of Addis Ababa frequent power interruptions become common & usual in every place, including at international and continental meeting occasions. Now the power interruptions become common problems in all parts of the country and a big challenge for the company. Unless this problem get immediate remedy it may significantly hamper the country economy growth and worsen the lives of citizens.

Figure 1 power system layout of the Ethiopian Electric



Source: Mehert Debebe ex EEPco CEO

1.2 Problem Statement

The availability of reliable power supply at reasonable cost is crucial for economic growth and development of a country. Due to this, Electric power utilities throughout the world strive to meet the customer demands with a high quality, economic and reliable power supply. The impact of electrical power on the growth of industrialization is that the electric power in particular is considered as the key to industrialization and an engine for the growth and development. The reliability or quality of electricity supply had emerged as a key issue, because of the greater dependence of modern economies on power (Munasinghe and Sanghvi, 1988). The critical issue faced by our country is that the demand for electric power is high and there is a critical power supply problems.

The significance of implementing interruption free electric power supply is crucial for reliable economic development and for social welfare. However, frequent power supplies related problems currently more aggravated. This indicates there is a chronic not well known problem in the sector. Electric power interruption is power outages and blackouts due to various reasons. Interruption is the power quality problem with the most perceivable effect on facilities. It generally affects the industrial sector, particularly the continuous process industry. In addition, the communication and information processing business is also significantly disturbed. Consequences of short interruptions are similar to the effects of voltage sags.

Now days in Addis Ababa electric power becomes a back bone for every business and non-business endeavors and for the livelihood of every inhabitant. But electric power interruption becomes a serious problem in the city in everywhere. The number of outages is very high and it takes long time for service restoration. Due to this every aspects of business and non business activities and day to day lives of the city residents are negatively affected and highly complained with this problem. Moreover the power interruptions cause wastage of power or power losses significantly.

Therefore, for the purpose of demonstrating appropriate action, the investigation should identify the main constraints in electric power supply to ensure interruption free electric power supply. More specifically, the following research questions need to be addressed:

1. What are the typical constraints found in electric power supply?

2. How to classify these constrains for easier identification?
3. What are the current industry practice as well as research advancements in resolving constraints?
4. How to manage and prioritize the constraints?
5. What are the major consequences of the constraints?

1.3 Objectives of the study

The goal of the research is to identify the basic causes of electric power interruption for the purpose of proposing the appropriate remedy or the power interruption management system. Power interruption is defined herein as the outage or blackouts of electric power due to various reasons.

General Objectives

- The aim of the research is to identify the fundamental causes and consequences of electric power interruptions & proposes appropriate solutions.

Specific objectives

- To identify the root causes of power interruptions & its characteristics.
- To rank the constraints for prioritization purpose
- To identify the consequences of power interruptions.
- To Identify and ordering priority measures

1.4 Preliminary Literature Review

A preliminary literature review primarily focused on understanding of electric power interruption, loses, costs of power interruptions, key performance indicators of electric power supply, and methods of managing power interruptions.

1.5 Significance of the study

This study is presents a theoretical and practical implication for electric power interruption and lose. Second, this study will show the causes and impacts of electric power interruptions and importance of managing power interruptions and lose and its urgency. The finding identifies the focal problem and priority areas for decision makers. Additionally, it will also provide a reliable data in relation to the cause of power interruption and lose for researchers, academics and students.

1.6 Scope of the study

The study is limited to Addis Ababa city, but data gathering covers source of service those located out of the city in various parts of the country. For this purpose data is collected from the seven processes of the company. Data are collected from generation, transmission, distribution, marketing and sales, human resource, MIS and from finance process. Externally, data collected from residential, commercial and industrial customers based on oral questions and interviews. In regarding to power infrastructure observation is applied. The study uses the recent four consecutive year power interruption data and based on representative data gathering and observations.

1.7 Limitation of the study

The research face difficulty to access all relevant data and few respondents are not willingness to provide the required information and may hide the real facts. Time and budget are always in scarce which also view come upon this study.

1.8 Organization of The paper

The paper is organized into five chapters:

Chapter One: Introduction

It shows the over view of the company in which the study is conducted, and the problem of the study also stated clearly in this part. Moreover this part illustrates the general and specific objective of the study, significance, scope and limitation of the study.

Chapter Two: Methodology

It demonstrates the data the research utilizes, the population of the research, sampling techniques, the method of sample determination and data collections, and data analysis and interpretations techniques.

Chapter Three: Literature Review

The literature review covers the conceptual frame work of the study, for this purpose various articles, journals and books related to the topic of the study are referred. The literature review focuses about power grid systems, reliability and availability of power supply, power wastage, power

interruptions, cost of poor electric power quality, problems in electrical network, and causes of poor electric access in Africa and power outage.

Chapter Four: Analysis and Interpretation of data and Findings

It includes the analysis and interpretation of the recent four year power interruptions secondary data and primary data collected from employees and power customers. And as per the primary and secondary data SWOT and root cause analysis is done. Based on the qualitative and quantitative analysis major findings are identified.

Chapter Five: Recommendation

This part offers the possible remedy of power supply related problems for improving future estimates. Recommendation is forwarded for tackling the root causes of power supply related problems.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

The literature review focuses on the causes and effects of electric power interruptions and loses on the basis of theoretical and practical perspectives. This review focuses on the electric power supply concepts in particular about power grid systems, reliability and availability of power supply, power wastage, power interruptions, cost of poor electric power quality, problems in electrical network, and causes of poor electric access in Africa and power outage.

2.2 Electric Power Outages

As indicated in various literatures electric Power outages are a problem of both developed and developing countries. Whereas, the extents of their magnitude, their frequency, as well as their underlying causes differ from one group to the other. Developing countries turn out to be more affected by insufficient provision of electricity power. (Lee and Anas, 1992, Steel and Webster, 1991).

2.4Strategies for decreasing interruption

There are two possible strategies for decreasing interruption indicators, this strategy applied in distribution networks and in transmission systems.

2.4.1 In distribution networks

The first possible strategy in distribution networks is reduction of the number of interruptions. This strategy covers the application of Preventive maintenance, replacement the components which have reached the end of age, isolated or tree wires in over head lines, and apply it periodically and protection against animals. Reduction of times of interruption is the other strategy which incorporates, atomization of distribution network, reconfiguration changes of system depending of the fault, fault current protection and forming dispatching center. The final strategy is reduction of number of affected customers through permanent reconfiguration of the distribution network by adding more and shorter output feeders from substations and distribution points and Protective devices, i.e. recloses, sectionalizes, automatic switches. (Hafez El-Salmawy, Kamelia Youssef, Shereen Abdulla, Mohamed Gamea, and Khaled Hamdy December 19-21, 2010, Tracking the Reliability indicators In the Egyptian Electric Power)

2.4.2 Transmission system

A strategy in transmission system includes adequate preventive maintenance, adoption of preventive maintenance rather than breakdown maintenance; avoid overloading of transformers and lines, automation control of system operation, employ better quality equipments (protective relays, switchgears…), minimization voltage level transformations, and coordination of protective relays settings and improve power quantity. (Hafez El-Salmawy, Kamelia Youssef, Shereen Abdulla, Mohamed Gamea, and Khaled Hamdy December 19-21, 2010, Tracking the Reliability indicators In the Egyptian Electric Power System)

The electric power system is composed of four interacting physical elements: energy generation, high-voltage transmission, lower voltage distribution, and energy consumption, or load. Two less tangible elements are also important to the operational systems that protect and control the physical elements, and the regulatory and governance structures that shape the system's evolution. A variety of technological and economic changes will alter both the demand for and supply of electricity in challenging ways. If regulatory policies and the technologies employed in the grid do not change, it is likely to be difficult to maintain acceptable reliability and electric rates. (Massachusetts Institute of Technology, 2011, the Future of the Electric Grid, AN INTERDISCIPLINARY MIT STUDY, p13)

Technologies exist that can meet these challenges effectively, but only if a number of regulatory policies are changed, necessary research and development is performed, and important data are compiled and shared. Several features of electric power systems are fundamental to their structure and operation. Generally not economical feasible to store electricity in bulk, the widespread deployment of new storage technologies and/ or high penetrations of electric vehicles may someday change this, but these developments are unlikely before 2030. It follows the electric power system must vary the supply of electricity to meet minute to- minute changes in demand and in the output of variable energy sources such as wind and solar generators. Power systems must be built with enough capacity to meet expected peak demand with some excess capacity for safety.

Electricity flows through many transmission paths from generators to customers, and individual flows cannot be controlled with precision. An electric grid is a natural monopoly it would be prohibitively expensive to have multiple overlapping grids in any region. The need to maintain instantaneous balance of supply and demand, limits on transmission line capacities, and other

features require central coordination of short-term system operations. (Massachusetts Institute of Technology, 2011, the Future of the Electric Grid, AN INTERDISCIPLINARY MIT STUDY, p13-14)

2.5 Electricity Reliability

Reliability can be defined as the ability of the power system components to deliver electricity to all points of consumption, in the quantity and with the quality demanded by the customers. All components of the electric utility system, including generation, transmission, and distribution, contribute to reliability. Reliability of electricity supply is the degree to which the retail service provides the service as it was promised. (Dabholkar et al, 1996).

Since electricity is entwined with every aspect of day-to-day life, the issue of reliability is paramount. In addition to the inconvenience experienced by consumers during prolonged periods without electricity service, a power outage can literally mean the difference between life and death. From specialized care equipment such as dialysis machines to everyday heating and cooling devices like air conditioners or furnaces, the impact of a power interruption on consumers can be significant. Interruptions can result in fatalities, injuries, days of lost productivity and thousands of dollars in production losses and equipment repairs.

Reliable power supply, i.e. low number of interruptions, timely and reliable information in case of a disturbance, short restoration time, rapid response and interest to complainers and standard technical quality (Safe operation of electric devices) are customer expectation from electric utility. (Hafez El-Salmawy, Kamelia Youssef, Shereen Abdulla, Mohamed Gamea, and Khaled Hamdy December 19-21, 2010, Tracking the Reliability indicators)

2.5.1 Reliability Measurement

Factors that determine power reliability:

1. Longer circuits lead to more interruptions. It is easier to provide higher reliability in urban areas; line lengths are shorter, and more reliable distribution systems are more economical.

2. The distribution supply configuration greatly impacts reliability. Long radial lines provide the poorest service; grid networks provide exceptionally reliable service.

3. Higher primary voltages tend to be more unreliable; mainly because of longer lines.

Faults and interruptions have significant year-to-year variation because weather conditions vary significantly, age of electrical equipment, or performance of protective systems. These factor variations are translated into variations in the number of faults and in the reliability indices.

The three broad categories of service quality measures that are being considered are: Continuity of supply, technical quality and commercial quality

Table 1: Categories of service quality measures

Continuity of Supply	Technical Quality	Quality of Customer Service
Reliability of Power Supply	Physical Properties of power	Customer Services
Performance Indices (frequency and duration of interruption)	Performance indices (voltage variation, unbalance, sags, swells, flickers, harmonics).	Performance Indices (complaints, response time to solve complaints, appointed with consumers

Source: (Hafez El-Salmawy, Kamelia Youssef, Shereen Abdulla, Mohamed Gamea, and Khaled Hamdy December 19-21, 2010)

Measures of reliability, such as the frequency and duration of power interruptions, the three reliability metrics:

1. SAIFI- System Average Interruption Frequency Index, designed to give information about the average frequency of sustained interruptions per customer over a defined time, it is derived from the following Equation:
   Total number of customer interruptions / Total number of customer served.
2. SAIDI- System Average Interruption Duration Index, designed to provide information about the average time that customers are interrupted, it is derived from the following Equation:
   Sum of customer interruption duration / Total number of customer served.
3. CAIDI- Customer Average Interruption Duration index, the average time required for restore service to the average customer per sustained interruption. It is derived from the following Equation:
4. Sum of customer interruption durations / Total number of customer interruptions (i.e. CAIDI= (SAIDI/ SAIFI).

(Hafez El-Salmawy, Kamelia Youssef, Shereen Abdulla, Mohamed Gamea, and Khaled Hamdy December 19-21, 2010, Tracking the Reliability indicators in the Egyptian Electric Power System)

2.6 Rationality of Reliability

The original purpose of the electricity grid was to supply power to the light bulb. Today, the grid provides power to a wide variety of critical applications. It includes: Powers life support system in residences as in home care expands; powers the essential life-saving services in hospitals; powers heating and cooling now critical to life and safety for many; powers the communications needed for consumers to call for help and emergency crews to respond accordingly; powers critical devices such as the pumps that protect cities, businesses and homes from flooding; powers the processes in water treatment plants needed to supply safe drinking water; powers the communication towers and central telephone stations essential in the communications infrastructure; powers the digital/continuous process industries that are the lifeblood of an industrial society; and powers elevators or escalators used for egress during an emergency situation.

The effects of power outages go beyond the annoyance experienced from the outage itself. In addition to being responsible for deaths and injuries when they interfere with elements of day-to-day life, outages pose a real public safety hazard. When an area of a city loses power, police and firefighters must be diverted from protecting neighborhoods to recovery operations and to make sure citizens are safe. When the power fails, many residents turn to candles for light and generators for power—both of which introduce an inherent danger. Similarly, the transportation infrastructure is compromised as traffic lights go dark and police are diverted to direct traffic. (Galvin Electricity Initiative, www.GALVINPOWER.ORG)

2.7 Technical loss in electric power system

There are two main components of technical loss in transmission and distribution systems. One is loss in the lines while the other is loss in transformers. Common reasons for high electric energy loss on the line are low voltage level compared to the size and length of the conductor, low power factor, load unbalance in the phases, harmonics in the current and voltage, improper design or installation using inappropriate materials and components, etc. There are at least three transformers in a power system transmission from generation point up to the consumer premises.

These are step-up transformer at the generator switch yard, the step-down transformer at the distribution center, step-down to low voltage (400 V, 220 V) level. The transformer efficiency varies from 96 to 99.5 depending on the capacity, load, design, etc. Older transformers have high loss or lower efficiency. (International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering)

2.8 Cost of poor electric power quality

Electricity interruption frequencies, the duration of the interruptions and/or load limitation have been known to cause a lot of difficulties for specific industries particularly those that use electricity as a resource. The electricity interruptions or fluctuations have had varying effects on businesses including but not limited to instantaneous damage to semi-finished goods, associated costs incurred in repairing equipment's and losses accrued from delayed or cancelled orders. Two types of interruptions have been identified. They are planned interruptions and unplanned interruptions.

Planned interruptions have a mitigating effect on business operations because potential damage to semi-finished goods or materials can be minimized through the switch to alternative sources of electrical power such as generators and solar panels. Cost incurred due to delayed or cancelled orders or equipment repairs can also be avoided because production and delivery schedules can be adjusted ahead of time. However, the costs of alternate power sources such as power generators, as well as expenditure on overtime pay to staff and outsourcing service cannot be avoided (Wang, 2002).

Unplanned interruptions, however have unmitigated and sometimes unforeseeable effects on business operations. Often, there are damages that tend to affect product quality, semi finished goods and costs incurred in repairing, and in delays in the delivery of orders. The cancelations in delivery are bear by businesses and that increases the operation and maintenance costs (Lai, Yik and Jones, 2008).

The most important function of a recent electric power system is to provide electric power to its customers at the lowest possible cost with acceptable reliability levels. The two aspects of economics and reliability often conflict and present power system managers, planners, designers and operators face with a wide range of challenging problems. The price that a customer is

willing to pay for higher reliability is directly connected to the interruption costs created by power failures. (Galvin Electricity Initiative, www.GALVINPOWER.ORG)

Poor Power Quality can be described as any event related to the electrical network that results:

1. A sudden power supply failures (breakers tripping, fuses blowing).
2. Equipment failure or malfunctioning
3. Equipment overheating (transformers, motors…) leading to their lifetime reduction.
4. Damage to sensitive equipment (production line control systems…).
5. Electronic communication interferences.
6. Increase of system losses.
7. Need to oversize installations to cope with additional electrical stress with consequential increase of installation and running costs and associated higher carbon footprint.
8. Penalties imposed by utilities because the site pollutes the supply network too much.
9. Reactive power, as it loads up the supply system unnecessary,
10. Harmonic pollution, as it causes extra stress on the networks and makes installations run less efficiently,
11. Load imbalance, especially in office building applications, as the unbalanced loads may result in excessive voltage imbalance causing stress on other loads connected to the same network, and leading to an increase of neutral current and neutral to earth voltage build-up,
12. Fast voltage variations leading to flicker.

(Dr. Kurt Schipman, Dr. François Delincé ABB Power Quality Products, Belgium THE Importance of good power quality)

2.9 Main problems on Electrical Power Network

Disordering power supply occurs as a result of one or more technical problems, which occur on the electrical network during the process of power generation, transmission and distribution.

The main function of the electric power industry is to generate sufficient power for the use of their customers. Power generation includes the conversion of any form of energy to electrical energy. There are various types of generating stations depend on a source of input energy to drive the turbines of the generator. The sources of functional electrical powers in Ethiopia are hydro, wind, geothermal and diesel generating station by utilizing water, wind, heat and gas oil energies to rotate the turbine.

Power transmission is the delivery of bulk power from the generation station to the distribution point through the national grid. It uses several high voltage transformers, substations, and thousands of kilometers of transmission lines supported by steel towers. In Ethiopia the national grid is composed of several long radial transmission lines. In order to ensure the shortest distance to the desire destination the transmission lines constructed through the bush, forest and through difficult geographical locations.

The distribution sector of the electricity network is of paramount importance to the consumers. It is at this point that high voltage supply from transmission substation is being stepped down to low voltages of 33/11KV for industrial consumers and 230/415V for domestic consumptions. At this point, the consequences of all the problems emanating from all other sections are being felt. (G. Adedokun, M.Eng. and I.B. Osunpidan,,November 2010, The Pacific Journal of Science and Technology Volume 11. Number 2.)

2.8.1 Problems that arise at different Stages of Electrical Network

2.8.1.1 Possible Problems in Power Generation

The possible problems in power generations may include:

1. Insufficient power generating station: This happened when all the installed generators are working to their maximum capacity and not be able to meet the demand of the population.
2. Lack of maintenance culture: When there is no proper maintenance of the installed generators and other generating equipment. This condition will be worst if the generating stations are old and they require routine maintenance. Generators are being managed when they developed minor faults, and this makes them to generate below their rated capacity until they finally brake down.
3. Climatic Condition: The major effect of climatic change on the operation of electric power systems includes the inadequate inflow of water into the reservoirs of the hydro-generating stations. When the water level is very low, the potential of water reduces.
4. Poor technological development: Because of the low technological condition of industry that lack modern testing equipment which makes operations and maintenance easier and faster. This includes the application of old methods in operation which may be time consuming, inaccurate, and often difficult.
5. Lack of courage and motivation: This could be as a result of being deficient in periodic training and work-shops to improve and update knowledge or inefficient pavement and

poor performance management. All these factors impact their dedication to work which may have a direct impact on the smooth running of the power operation

6. Shortage of staff: The power industry is one of the industries that have the largest population of workers; in particular the technical section that requires large numbers of staff may be understaffed.
7. Poor management: Management is one of the major problems which impact the efficiency of any industry.
8. Human error: As human beings are bound to make mistakes, during the process of power generating operations, the state of mind of the operators can often lead to power failure.

(G. Adedokun, M.Eng. and I.B. Osunpidan,,November 2010, The Pacific Journal of Science and Technology Volume 11. Number 2.)

2.8.1.2 Possible Problems in Power Transmission

The possible problems in power transmission may include:

1. Vandalism: This is ignorant destruction of public or private property. Vandalism of materials and equipment is the greatest danger posed against the power industry and it is the only single act that if not properly addressed will render the efforts of government and power industry useless. This is mostly common in the rural areas; especially on the part of the transmission lines that pass through the forest areas. The most targeted items include; aluminum conductors, pin insulators, stay rods, transformers, and energy meters. The motives of these vandals are economic in nature but their actions put their lives at very high risk. Whenever any electrical equipment is being vandalized, it always takes a long period of time before reconstruction.
2. Bush Burning: During the dry season, farmers and cattle ranchers set fire to the bush under transmission lines. The resulting tick smoke causes flashover between towers and phase conductors of the transmission lines which leads to forced outage.
3. Lack of modern testing equipment: The common faults on transmission lines include; short circuits, open circuits, and earth faults. Lack of modern equipments in the power industry, includes those equipments that indicates the exact point of the fault. Due to this the maintenance crew takes a lot of time tracing the transmission lines of several kilometers by foot, inside the bush. This is a difficult task and is time consuming. The feeder concerned is likely to be in darkness for a long period of time.

4. Storms and lightening strike: This is mostly common during the raining season, as rain always accompanies storm lightning strikes; this causes a lot of damages to conductors, insulators, towers, poles, and cross arms. Lightning also causes over current and flashover that consequently trips breakers. This often leads to power outages for a period of time that the repair of the affected device or material will be carried out.
5. Construction activities and accidents: There used to be spiking of transmission lines by construction machines during the process of road construction. As most of the transmission lines are constructed very close to the main roads, a lot of damage can be caused to the transmission lines. There were also some cases of motor vehicles running into towers and poles.
6. Trees growing under transmission Lines: As longer parts of transmission lines are being run through the bush and forest areas, trees tend to grow under the transmission lines. If left unclear they may grow to the height of the transmission lines. This often leads to earth faults and over current flows when the fresh tree bridges two or more current carrying conductors.

Incompliance of operators: During the load fluctuation, the monitoring engineers at the National Control Center may attempts to regulate frequency in order to prevent system collapse. The engineer will therefore pass information to the operator at the desired transmission station to load or unload some of his feeders to normalize the frequency. At times, some operators failed to comply and this lead to system collapse, which contributes to irregular power supply. (G. Adedokun, M.Eng. and I.B. Osunpidan,,November 2010, The Pacific Journal of Science and Technology Volume 11. Number 2)

2.8.1.3 Possible Problems in Power Distribution

The possible problems in power distribution may include:

1. Overloading of equipment: The distribution network may undergoing severe overloading due to limitation in transformer capacities. This overloading normally results in failure of distribution transformers or melting of protective devices, like fuses. At times, this overloading results in low voltages that may not be useful for most domestic purposes.
2. Illegal connections: Users of electricity may not have formal business arrangements with the supplier; they may get their houses connected illegally. This results in the inability of the supplier to account for their true customers and plan for the load demand by them. Some

people may hang their wires to the distribution lines in the night when nobody would check them. They make use of low rated cables; this normally causes sparking and very serious damage to the distribution lines.

3. Corruption: Some of the staff of the supplier who distribute bills and take meter readings may undertake corrupt practices. Corrupt officials may go to the extent of adjusting the energy meters for some amount, intimidating the consumers with disconnection, sending fictitious bills, and extortion of illegal money from consumers who have outstanding accounts. This has a negative effect on the smooth running of the power industry, as they cannot meet their expectations. Consequently, they are unable to finance their project effectively due to shortage of funds.
4. Power wastage: Consumers of electricity may be ignorant of their usage. They leave their security lights on during the daytime and leave refrigerators and other electrical appliances on in the offices and shops over the weekends. This results in higher demand and contributes to interruption of power supply.
5. Defective Appliances: Consumers may using defective or faulty home appliances normally results in damage of electrical installation equipment and invariability causes variability in the available of power supply.
6. Poor installation of electrical appliances: Installations may be carried out by unqualified electricians. A large number of this kind of installation results in damages to electrical distribution equipment like transformers, etc …

(G. Adedokun, M.Eng. and I.B. Osunpidan,,November 2010, The Pacific Journal of Science and Technology Volume 11. Number 2)

2.10 The causes of poor access of electricity in Africa

The major causes of a poor access to electricity in Africa are: Poor performance, resulting in poor quality of supply and service and an inability to meet growing electricity demand, insufficient managerial and technical skills to do the job, inability of the African country's government to fund expansion or refurbishment, or to attract private sector investment into the power sector, lack of maintenance of the existing facilities due to inadequate finance/technical leading to reliability problems, inappropriate tariffs, often resulting from political interference, with tariffs below marginal costs, poor governance or unstable governments due to regional and

ethnic conflicts, poor economic status of African states especially south of the Sahara, inadequate revenue collection mechanisms, and therefore credit unworthy businesses, inadequate rainfall which causes power rationing and all these have culminated in poor supply of electricity with its attendant effects on the operations of business. (Mkhwanazi (2003) and Olumuyiwa and Mnse, (2008))

CHAPTER THREE: METHODOLOGY

In order to realize comprehensive assessment (end to end/ inclusive assessment) of the power supply process, the data collection and analysis encompass both companies and end users of the service.

3.5 Research design

The research design is considered the reliability and relevance of data identification, assessing and interpretations of power interruption causes. The data gathering, analysis and the report writing process considered research ethics and unethical action strictly not in use. This research approached by descriptive method, using questionnaire to examine and assessing the contributing factors of power interruption. The finding and conclusion of the study depends on the utilization of statistical data collected and based on qualitative and quantitative data analysis.

3.6 Source of data & data gathering tools

The primary sources of data for this study are secondary and primary data. Data is collected internally from generation, transmission, distribution, marketing and sales, finance, human resource and from ICT process. Externally data are collected from residential, commercial and industrial customers.

Data collection covered both primary and secondary sources. Primary data are collected through questionnaires and observation while secondary data are gathered from relevant documents. Moreover in order to improve and strengthen the study and findings, I pass on articles, academic journals, and useful texts through different sources, such as library, emerald journals, academic books and relevant documents from the company.

3.7 Sample questionnaire distribution and collection

The methodological approach relies on collecting relevant data and survey is conducted. The questionnaires are made up of six main sections, each focusing on a specific aspect of businesses. Sections 1 and 2 aimed at collecting identity data and general information on the sampled units (experience, sector, educational background, position or status, service satisfaction temperament, etc.). Section 3 focused on the main idea of this study, which is assessment of

power interruption related problems. Sections 4 and 5 dealt with remedial actions-related issues. Finally, section 6 tries to capture what priority measures related questions.

Questionnaire is developed for electric power customers, for the service provider distribution and transmission operation staffs. Representative sample is determined based on random sampling method at 95% confidence level and 5% margin of error. As per this 384 samples is determined out of 523,944 electric power customers and 184 sample employees from a total 362 employees. The questionnaires are both close and open ended. The questionnaires have a 90% response rate.

In order to ensure a least bias and high generalization, each member of the population get equal chance of selection and a simple random sampling technique is utilized. A set of questionnaires are also administered randomly to every third person in the selection process.

The secondary data analysis is done based on the secondary data obtained from the service provider. For this purpose a four years (From year 2010/11 up to 2013/14) electric power interruption data, strategic plan of the service provider, employee data, customer data, collection data and energy audit data are collected.

3.8 Data analysis

In this research, I describe the constraints and performance of businesses in the context of failing electricity service. Further quantify and explain how establishments' performance is related to some of their characteristics, as well as to some characteristics of the environment in which they evolved. A descriptive analysis of the information applied and the analysis are done to evaluate how businesses' productivities are related to sustainable power supply.

Constraint identification and classification through a structured approach is the very first. The study applied review of various types of electric power interruption and power lose and their characteristics. Based on this understanding, a classification method developed and constraint factors are categorized for the purpose of constraint identification and ranking.

In this study description and inferential statistics, tabulation, coding and categorization are applied to draw accurate conclusion about the relationship about variables.

CHAPTER FOUR: DATA ANALYSIS, INTERPRETATION & FINDING

4.1 Secondary data Analysis

4.1.1 The year 2010/11 Electric power interruption

The analysis bases the year 2010/11power interruption data. The data consists of frequency of interruption, duration of interruptions, and fault of interruption and areas of interruption in the grid systems.

I. Frequency and duration of power interruptions

The power interruption is evaluated based on the frequency and duration of electric power interruption. Frequency indicates the rate of occurrence or the number of repetition of the power interruptions in distribution feeders and in others infrastructures. Whereas duration indicates the length of time the power interruption continues or exists in the power grid systems.

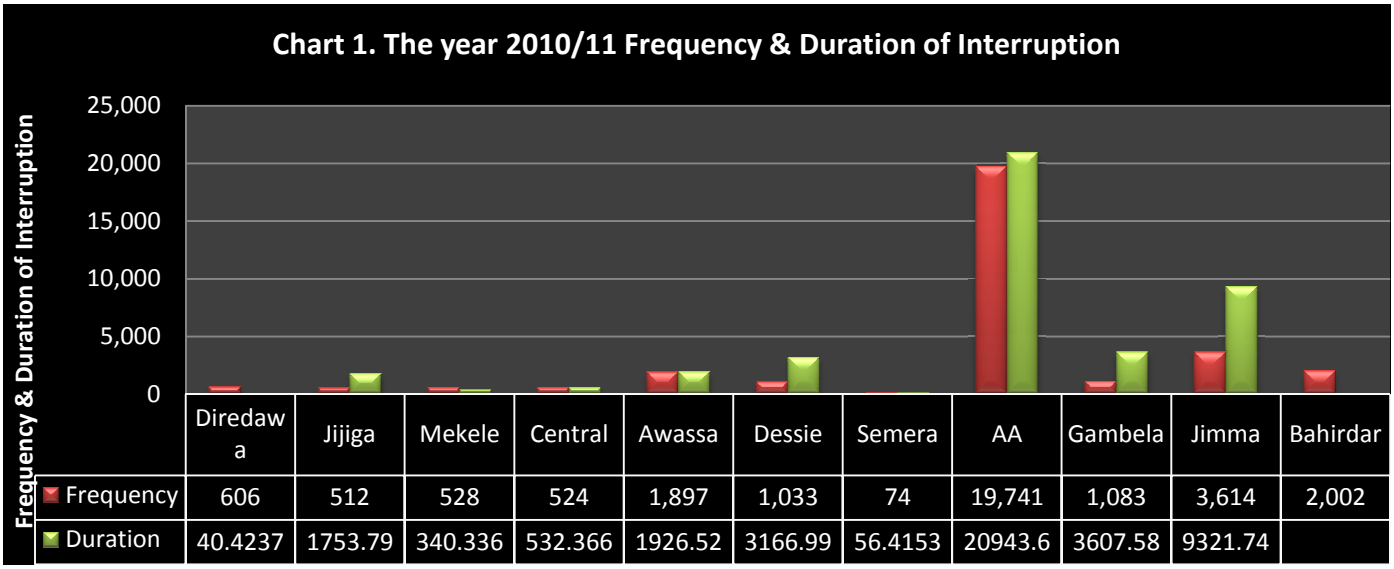
Chart 1 demonstrates the year 2010/11 electric power interruption frequency in numbers and the duration of interruption in hours for the service provider regions. According to the data the power interruption frequency and duration are higher than in both Sub-Saharan and international standards. As compared to others regions, both the frequency and duration of interruption is very high in Addis Ababa than others regions. The main reasons for this are more operational interruptions due to high relocation works, growth of higher power demands in the city leads over utilizations of the infrastructures contributes for the rate of interruptions and due to traffic conjunctions delay maintenance services. As per the data the frequency of power interruptions in number and the durations in hours are 19,741 and 20,943.6 respectively in Addis Ababa regions.

II. Faults for Electric power interruption

Faults of electric power interruption in the grid systems imply the failure that results electric power interruptions. The faults in the grid systems are categorized as:

- Distribution permanent earth fault (DPEF)
- Distribution permanent short circuit (DPSC)
- Distribution transient short circuit (DTSC)
- Distribution transient earth fault (DTEF)
- Transmission line problem (Fault on 45, 66,132,230KV and above) (TLP)

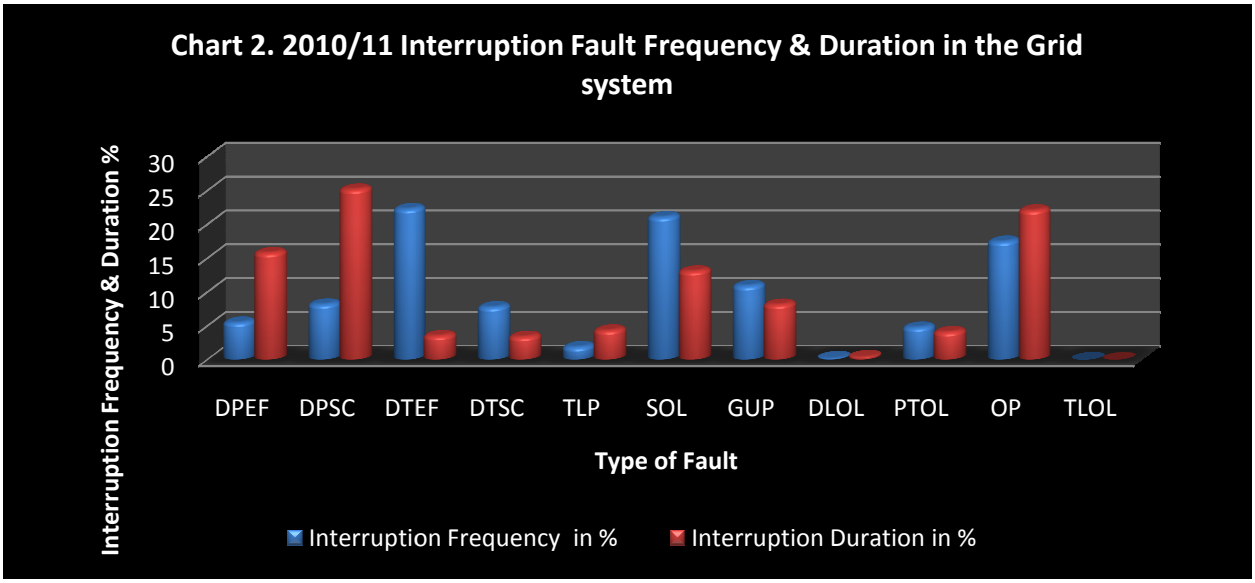
- System over load (SOL) (When the load carrying capacity of the national power supply system is below the demand due to different reasons even in the presence of enough energy)
- Generation unit problem (GUP) (Under Frequency Outages due to Generation Unit Failure).
- Distribution line over load (DLOL) (When medium Voltage Feeders are loaded beyond their capacity or CT ratio)
- Power transformer over load (PTOL) (When the Load is beyond the Capacity of Substation Transformer)
- Operational (OP) (When part of the system gets Interrupted Voluntarily for Maintenance ,Load Transfer ,New Transformer Erection, commissioning etc).
- Transmission line over load (TLOL) (when high voltage transmission lines of 45KV and above are loaded beyond their capacity).



	Diredawa	Jijiga	Mekele	Central	Awassa	Dessie	Semera	AA	Gambela	Jimma	Bahirdar
Frequency	606	512	528	524	1,897	1,033	74	19,741	1,083	3,614	2,002
Duration	40.4237	1753.79	340.336	532.366	1926.52	3166.99	56.4153	20943.6	3607.58	9321.74	

Source: Author survey 2015

As per the year 2010/11 interruption data, the major faults in the grid systems are described in chart 2. As indicated in Chart 2 distribution transient earth fault (DTEF), operational (OP) and system over load (SOL) interruptions counts 50% of the power interruption frequency. Distribution permanent short circuit (DPSC), distribution transient short circuit (DTSC), and generation unit problem (GUP) (Under frequency outages due to generation unit failure) each of them had 5% up to 10 % contribution for power interruption frequencies.

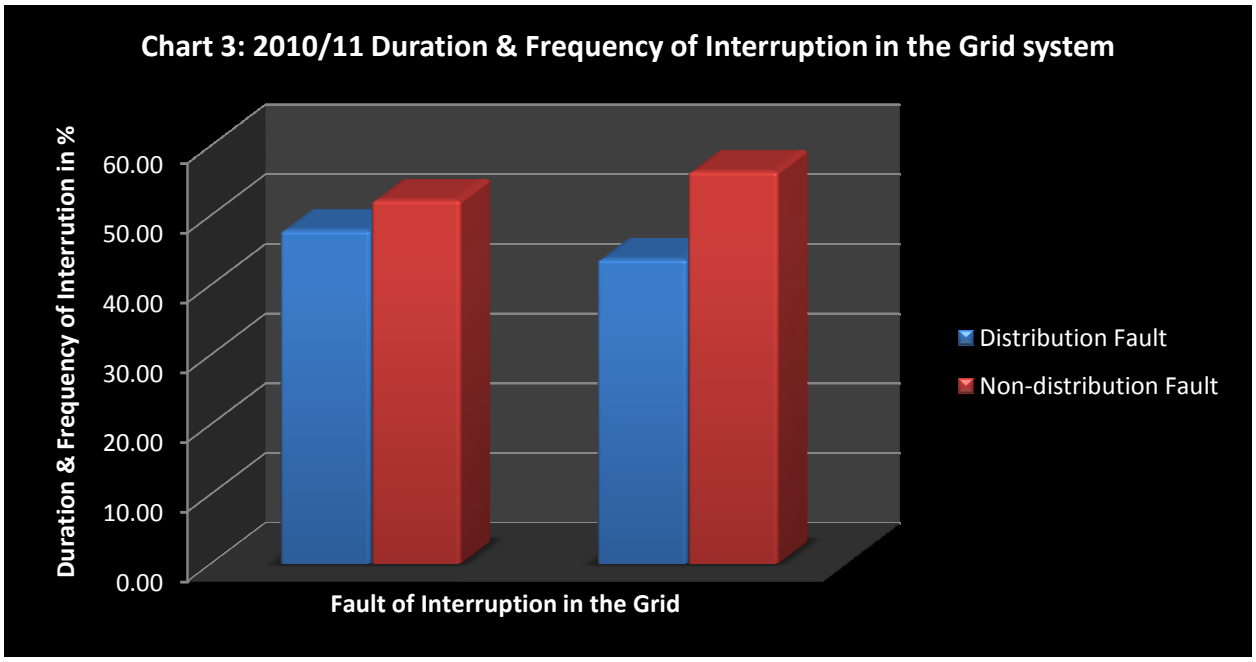


Source: Author survey 2015

Regarding to duration of fault of interruption in the year 2010/11 in Addis Ababa shows significant figure. As per chart 2 distribution permanent earth fault (DPEF), distribution permanent short circuit (DPSC) and operational (OP) (When part of the system gets interrupted voluntarily for Maintenance ,Load Transfer ,New Transformer Erection, commissioning etc) in combination contributes 63% for duration of faults. System over load (SOL) (When the load carrying capacity of the national power supply system is below the demand due to different reasons even in the presence of enough energy) and generation unit problem (GUP) (Under Frequency Outages due to Generation Unit Failure) had 13% & 8% duration of fault respectively.

III. Electric Power Interruptions in the Grid Systems

An electrical grid is an interconnected network for delivering electricity from suppliers to consumers. It consists of generating stations that produce electrical power, high-voltage transmission lines that carry power from distant sources to demand centers, and distribution lines that connect individual customers. The year 2010/11 power interruption data in Addis Ababa indicates the power interruption occurs through the grid systems significantly. As shown in chart 3 the data indicates 56% of the power interruption frequency was due to distribution fault whereas 44% the interruption non distribution faults.



Source: Author survey 2015

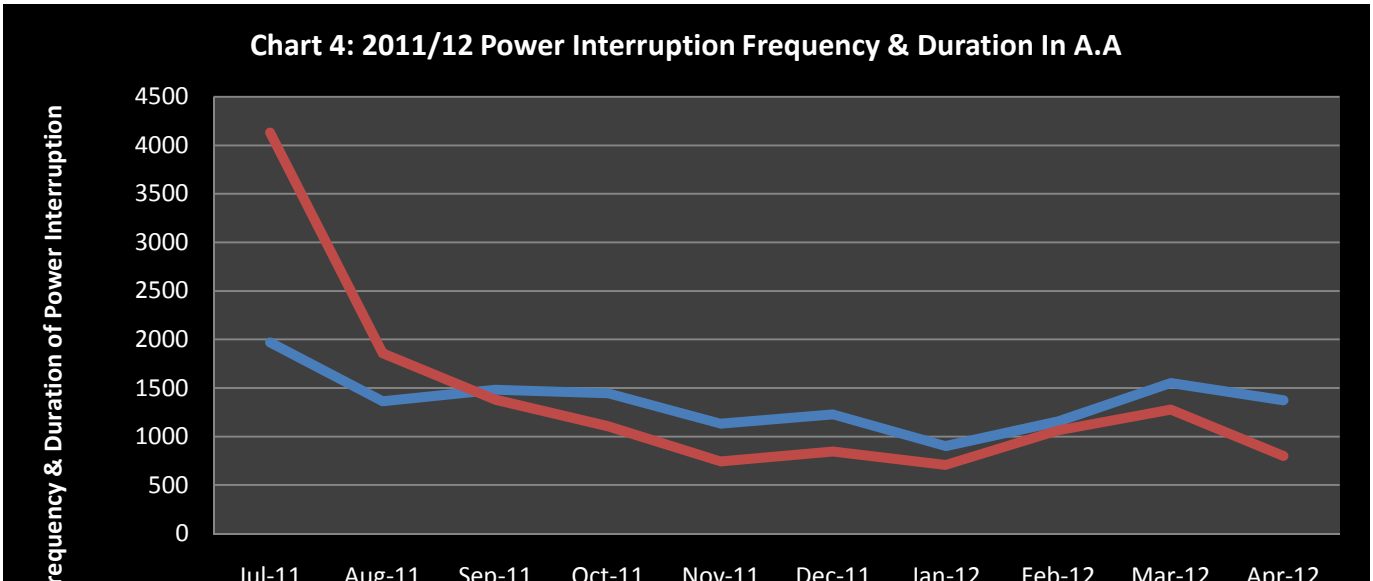
Regarding to the duration of interruption; 47.84% happened in distribution system while 52.16% in non distribution areas. As per the data both frequency and duration of faults had greater figure in non distribution areas. The average results of frequency & duration of faults in distribution and non distribution areas were 45.77% and 54.33% respectively.

4.1.2 The year 2011/12 Electric power interruption

The analysis bases the year 2011/12 power interruption data. The data consists of frequency of interruption, duration of interruptions, and fault of interruption and areas of interruption in the grid systems.

I. Frequency and duration of power interruptions

Chart 4 indicates the ten months electric power interruption frequency and duration of Addis Ababa Regions for the year 2011/12. According to the data the average power interruption frequency is 1361.7 and the average interruption duration in hours is 1390. If we look at the data the frequency and duration of interruption are greater in Ethiopian rain season (In July and August) than other months.



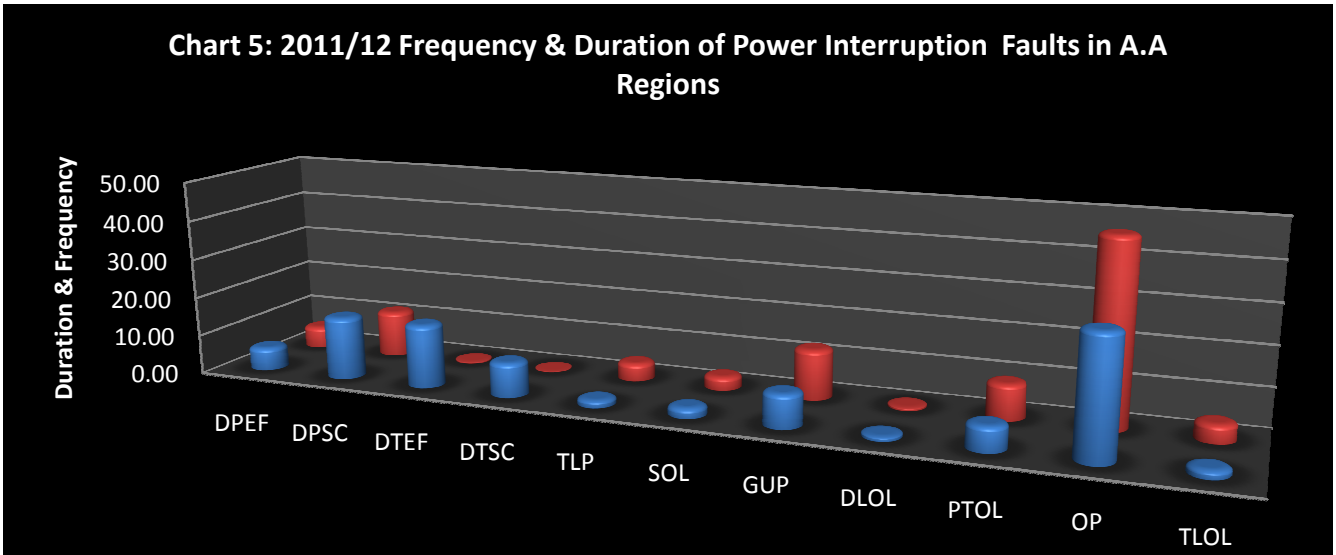
	Jul-11	Aug-11	Sep-11	Oct-11	Nov-11	Dec-11	Jan-12	Feb-12	Mar-12	Apr-12
frequency	1969	1365	1482	1448	1135	1231	904	1158	1552	1373
Duration	4,129.71	1,858.08	1,377.58	1,104.97	741.50	845.99	706.85	1,061.95	1,275.73	797.91

Source: Author survey 2015

II. Faults for Electric power interruption

Faults of electric power interruption in the grid systems entail the failure that results electric power interruptions. Chart 5 demonstrates the frequency and duration of power interruption faults of the grid systems for Addis Ababa Regions. The major faults were:

- Distribution permanent earth fault (DPEF)
- Distribution permanent short circuit (DPSC)
- Distribution transient short circuit (DTSC)
- Distribution transient earth fault (DTEF)
- Transmission line problem (Fault on 45, 66,132,230KV and above) (TLP)
- System over load (SOL)
- Generation unit problem (GUP)
- Distribution line over load (DLOL)
- Power transformer over load (PTOL)
- Operational (OP).
- Transmission line over load (TLOL).



	DPEF	DPSC	DTEF	DTSC	TLP	SOL	GUP	DLOL	PTOL	OP	TLOL
Frequency of Faults %	5.93	16.08	16.28	8.88	1.90	2.58	8.61	1.17	6.37	30.16	2.04
Duration Faults in %	5.65	11.89	0.52	0.31	4.64	3.50	12.73	0.81	9.08	46.26	4.59

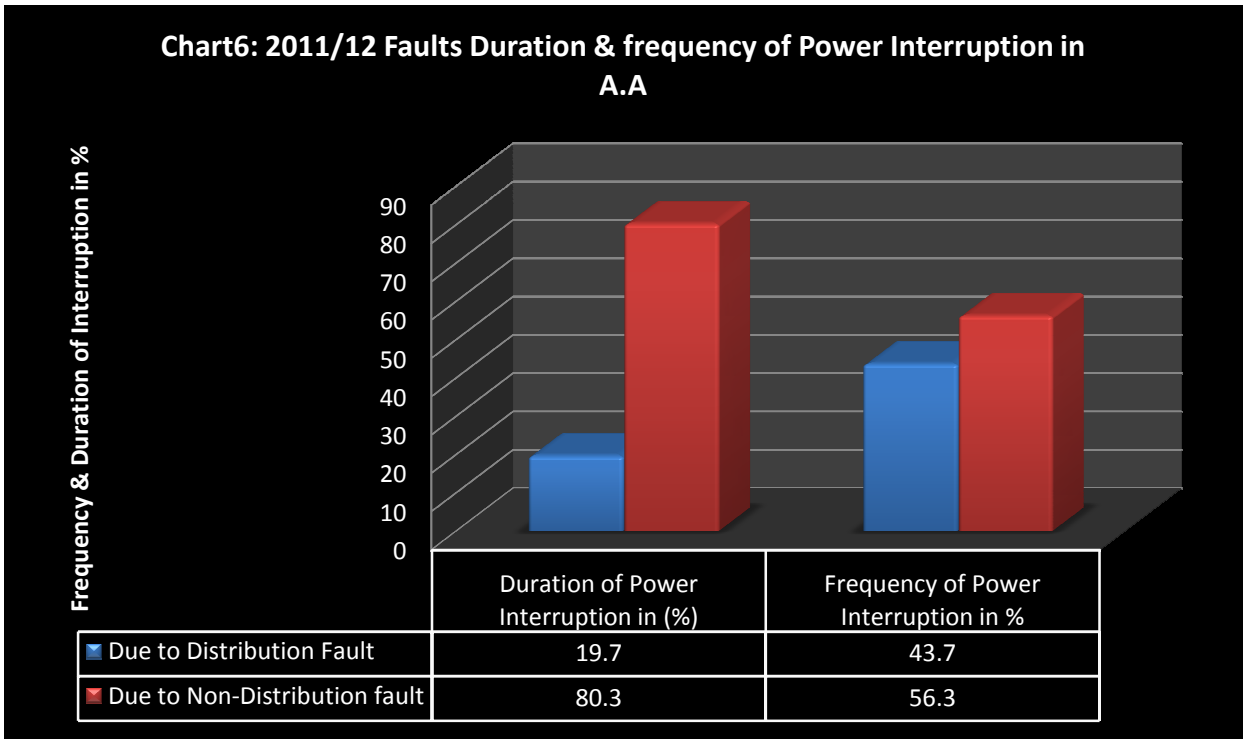
Source: Author survey 2015

Based on the data on chart 5 the frequency of power interruption for the purpose of operational duties only covers 30.16% frequency faults and faults frequency in distribution permanent short circuit (DPSC) and distribution transient earth fault (DTEF) in combination has 34.34% shares. Distribution permanent earth fault (DPEF), power transformer over load (PTOL), generation unit problem (GUP), and distribution transient short circuit (DTSC) have 5% Up to 9% frequency faults for the given year.

In the case of duration of faults the data depicts 46.26% fault duration is for operational interruptions and 11.08%, 9.08% and 5.65% in distribution permanent short circuit (DPSC), power transformer over load (PTOL) and in distribution permanent earth fault (DPEF) correspondingly. The shares of the other fault types are below 5%.

III. Electric Power Interruptions in the Grid Systems

Chart 6 reveals that the year 2011/12 power interruption frequency and duration data in the grid system for Addis Ababa regions. According to the data both the frequency and duration of power interruption has a great figure in non-distribution areas.



Source: Author survey 2015

Based on the data the frequency and duration of power interruptions in non-distribution areas are 56.3% & 80.35 respectively. Whereas the fault frequency and duration in distribution related area are 43.7% and 19.7% correspondingly.

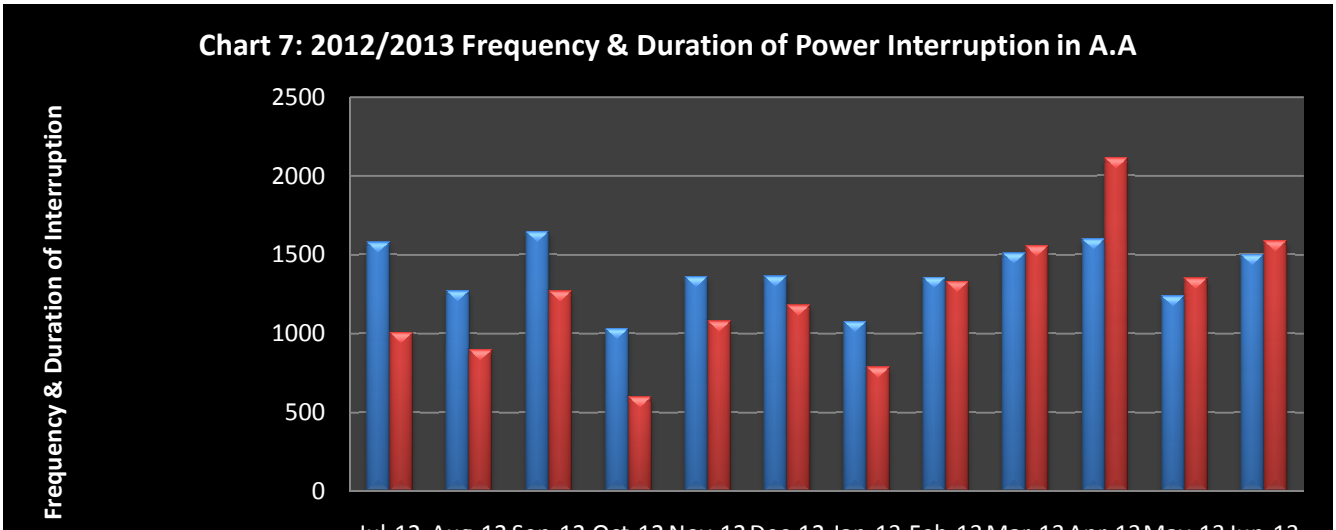
4.1.3 The year 2012/13 Electric power interruption

The analysis bases the year 2011/12 power interruption data. The data consists of frequency of interruption, duration of interruptions, and fault of interruption.

I. Frequency and duration of power interruptions

As per the data demonstrated in chart 7 the frequency of power interruption has a high figure in all months, particularly the figure is more than 1500 power interruption frequencies in July, September, March, April and June. Power interruption duration also has considerable figures, especially in the month of April the duration of interruption is 2113 hours. And also except

August, October and January the duration of interruptions are more than 1000 hrs for each month.



	Jul-12	Aug-12	Sep-12	Oct-12	Nov-12	Dec-12	Jan-13	Feb-13	Mar-13	Apr-13	May-13	Jun-13
Frequency of Interruption	1581	1272	1647	1033	1362	1365	1078	1357	1511	1601	1240	1501
Duration of Interruption	1006	896	1270	599	1079	1181	787	1331	1557	2113	1351	1588

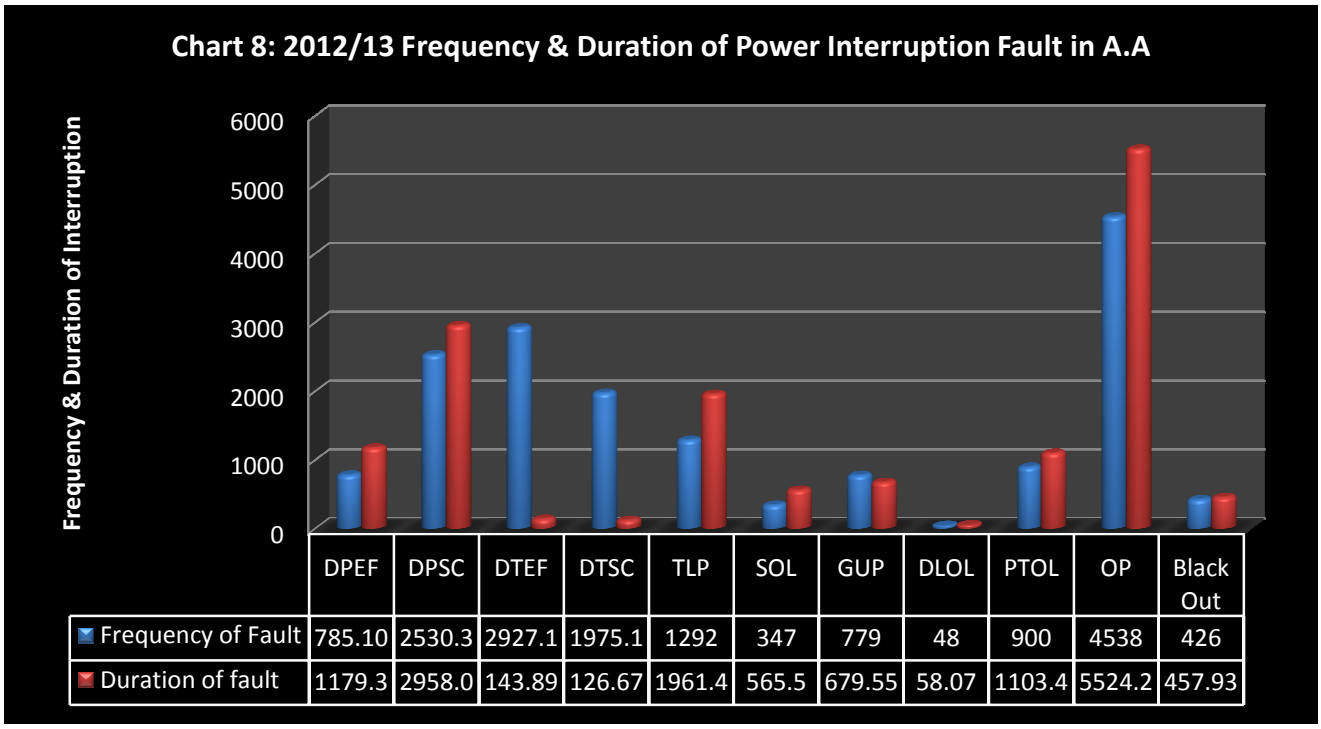
Source: Author survey 2015

II. Faults for Electric power interruption

Faults of electric power interruption in the grid systems mean the failure that results electric power interruptions. Chart 8 demonstrates the frequency and duration of power interruption faults of the grid systems for Addis Ababa Regions. The major faults were:

- Distribution permanent earth fault (DPEF)
- Distribution permanent short circuit (DPSC)
- Distribution transient short circuit (DTSC)
- Distribution transient earth fault (DTEF)
- Transmission line problem (Fault on 45, 66,132,230KV and above) (TLP)
- System over load (SOL)
- Generation unit problem (GUP)
- Distribution line over load (DLOL)
- Power transformer over load (PTOL)

- Operational (OP).
- Transmission line over load (TLOL).
- Black out a period of a massive power failure.



Source: Author survey 2015

As per the data on chart 8 frequency of fault for operational purpose is the highest (4538 frequency) and distribution transient earth fault (DTEF) is the second highest (2927 frequencies). Distribution permanent short circuit (DPSC), distribution transient short circuit (DTSC) and Transmission line problem (Fault on 45, 66,132,230KV and above) (TLP) have a highest fault frequency figures.

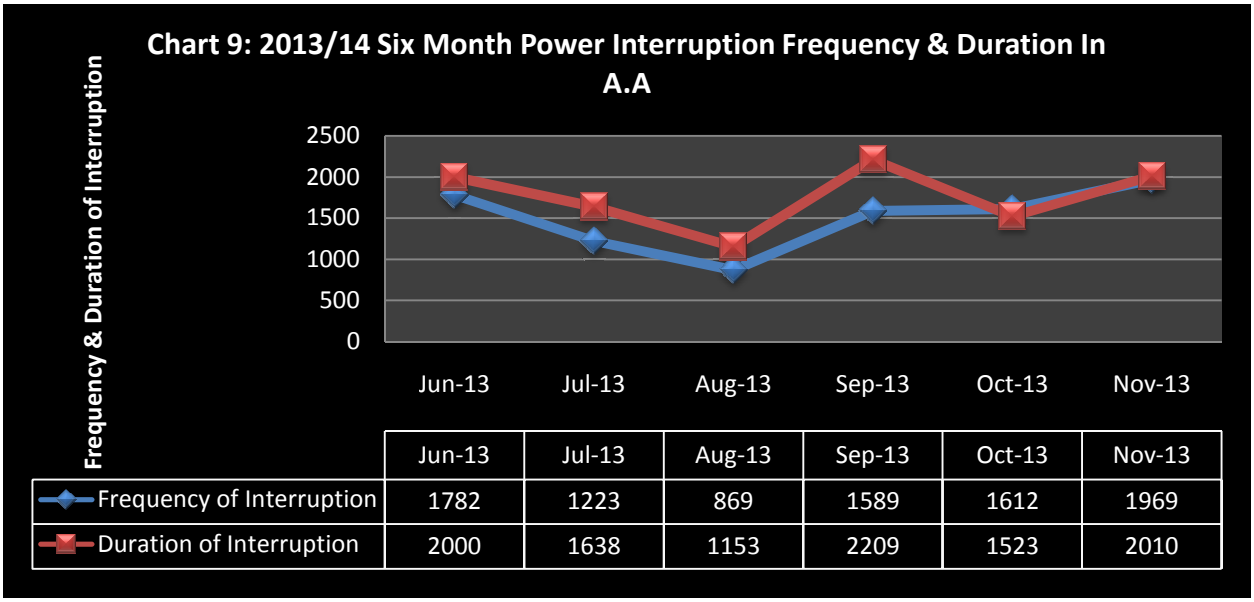
Duration of fault for operational purpose takes 5524 hours and this figure is very high in comparison with others type of fault durations. Distribution permanent earth fault (DPEF), distribution permanent short circuit (DPSC) and transmission line problem (Fault on 45, 66,132,230KV and above) (TLP) each of them have more than 1000hours fault durations.

4.1.4 The year 2013/14 Electric power interruption

The analysis bases the year 2013/14 six month power interruption data. The data consists of frequency of interruption, duration of interruptions, and fault of interruption.

I. Frequency and duration of power interruptions

The year 2013/14 the average six month frequency of interruption are 1507 and 1755duration of interruptions. The frequency of interruption is higher in November and June than the remaining months. As indicated in chart 9 the duration of interruption also more than 2000 hours in June, September and November.



	Jun-13	Jul-13	Aug-13	Sep-13	Oct-13	Nov-13
Frequency of Interruption	1782	1223	869	1589	1612	1969
Duration of Interruption	2000	1638	1153	2209	1523	2010

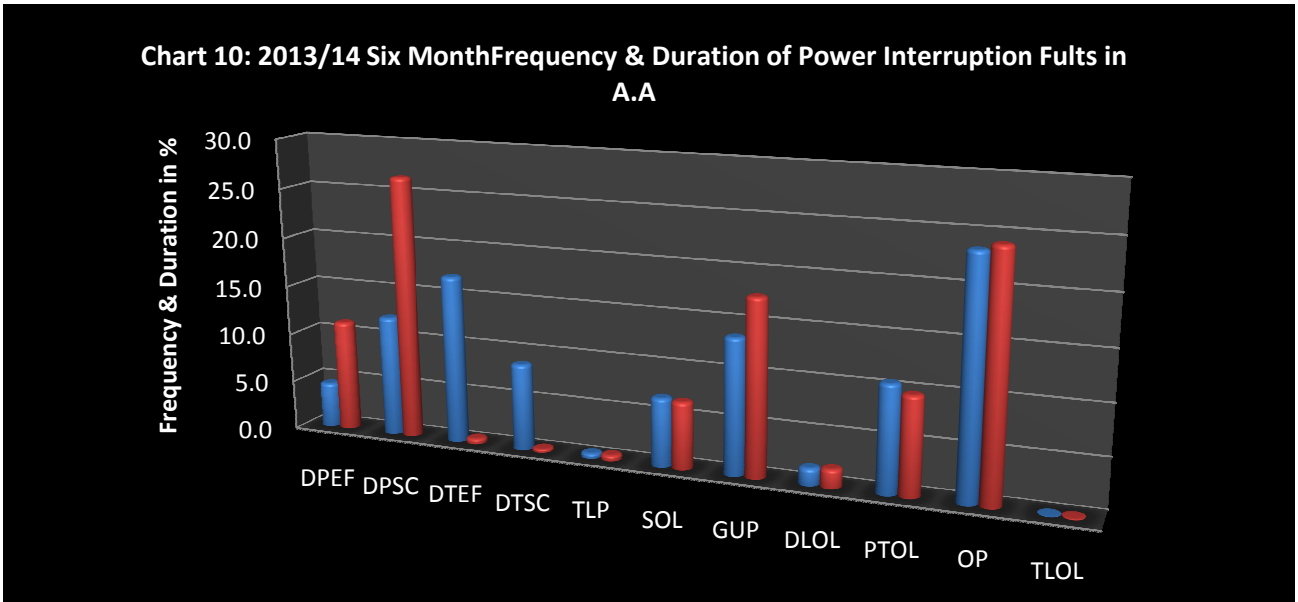
Source: Author survey 2015

II. Faults for Electric power interruption

Faults of electric power interruption in the grid systems imply the failure that results electric power interruptions. Chart 8 demonstrates the frequency and duration of power interruption faults of the grid systems for Addis Ababa Regions. The major faults were:

- Distribution permanent earth fault (DPEF)
- Distribution permanent short circuit (DPSC)
- Distribution transient short circuit (DTSC)
- Distribution transient earth fault (DTEF)
- Transmission line problem (Fault on 45, 66,132,230KV and above) (TLP)
- System over load (SOL)

- Generation unit problem (GUP)
- Distribution line over load (DLOL)
- Power transformer over load (PTOL)
- Operational (OP).
- Transmission line over load (TLOL).



	DPEF	DPSC	DTEF	DTSC	TLP	SOL	GUP	DLOL	PTOL	OP	TLOL
Frequency of Fault	4.6	12.2	17.0	8.8	0.6	7.0	13.7	1.8	10.7	23.5	0.1
Duration of Fault	11.3	26.6	0.6	0.4	0.6	6.8	17.7	1.9	9.9	24.1	0.1

Source: Author survey 2015

Regarding to the frequency of power interruption faults, the data in chart 10 indicates that power interruption faults for operational purpose weights 23.5% and distribution transient earth fault (DTEF) 17% from the total six month frequency of faults. Whereas distribution permanent short circuit (DPSC) and generation unit problem (GUP) has each of them more than 10% fault frequencies. The remaining each faults of frequencies weight under 10% as indicated in the data.

On the subject of duration of faults in operation purpose, distribution permanent short circuit (DPSC) and generation unit problem (GUP) collectively weights 68.4%. Distribution permanent earth fault (DPEF), system over load (SOL) and power transformer over load (PTOL)

individually weights 6% up to 11% duration of faults. The remaining type of faults has minor duration as compared to others.

4.1.5 Trends of Electric power interruption

Previously the power interruption makeup of each four year observed separately and now in order to have a clear picture about year to year change the four year data is analyzed afterwards. Interruption frequency index shows the number of frequency of faults per feeder and whereas interruption duration index demonstrates the duration of interruptions hours per feeder. Interruption frequency and duration index are computed as follows:

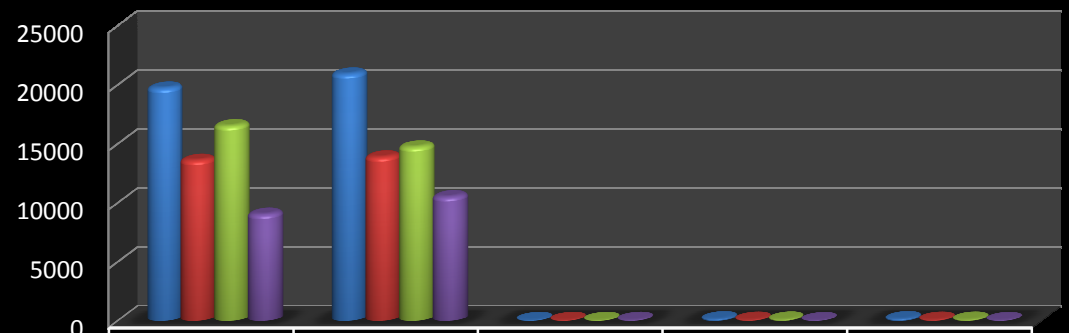
$$\text{Interruption Frequency Index} = \frac{\text{Total number of Interruption Frequency Per Reporting Period}}{\text{Number of Feeders}}$$

$$\text{Interruption Duration Index} = \frac{\text{Total Interruption Duration (in hours) Per Reporting Period}}{\text{Number of Feeders}}$$

As indicated in chart 11the interruption frequency and duration index is higher in the year 2010/11, and then it decreases in 2011/12. In the year 2012/13 the data shows increments of interruption frequency and duration index. The year 2013/14 half year data has also higher index and it indicates there is a higher possibility for index increment. Interruption frequency and duration's data also starts to increase in the year 2011/12 and forwards.

The presence of power rationing due to power shortage in the year 2011/12 highly increases the power interruption frequency and durations. The increments of year to year power interruption durations and frequency are due to aggravation of faults as a result of overutilization of power infrastructures in respond of the highly growth power demands. The others contributing factors for the increments are shortage of maintain ace inputs and wear outs the infrastructures in the years.

Chart 11: Four year Average Interruption Frequency & Duration per Feeder in A.A



	Frequency of interruption (No.) [A]	Duration of Interruption(Hr.) [B]	No. of Feeders [C]	Interruption Frequency Index [D = A / C]	Interruption Duration Index [E = B / C]
2010/11	19741	20944	105	188	199
2011/12	13,617	13,900	105	130	132
2012/13	16548	14758	105	158	141
2013/14 (six Month)	9044	10532	113	80	93

Source: Author survey 2015

4.2 Primary Data Analysis on the Bases of Questionnaire Responses

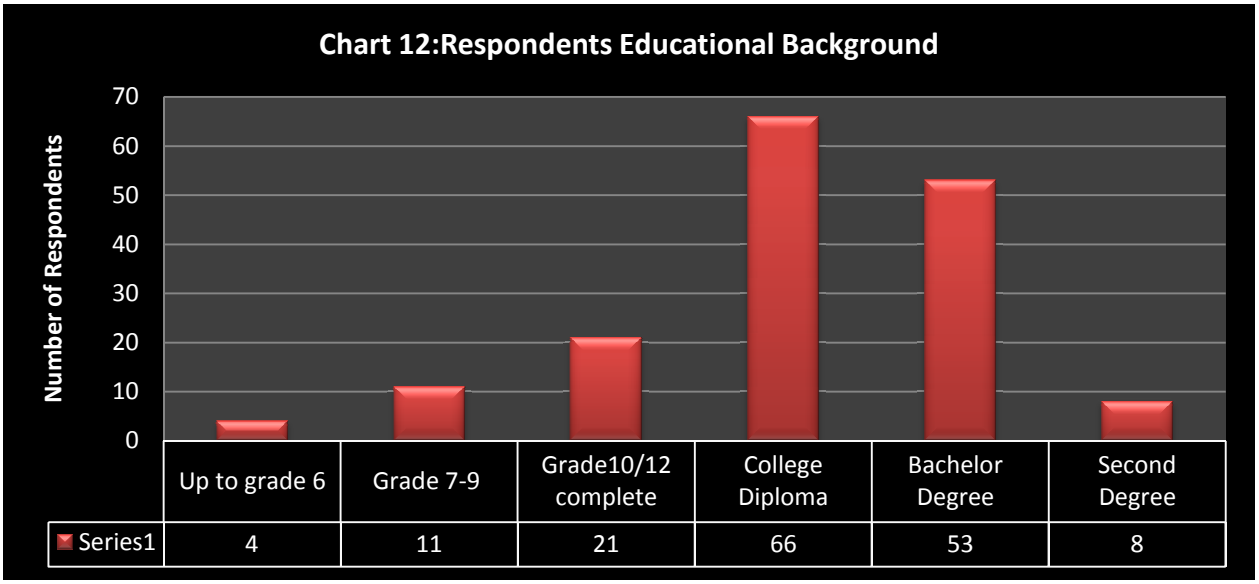
As described in the methodology, primary data are collected for the purpose of identifying the causes and effects of power interruptions. For this undertaking a questionnaire is developed for electric power customers, for the service provider distribution construction, distribution and transmission maintenance and for management staffs. The sample is determined based on random sampling method at 95% confidence level and 5% confidence interval. As per this method 384 samples is determined out of 523,944 electric power customers and 184 sample employees from a total 362 employees.

The questionnaires are both close and open ended, and from the total distributed question 90% of them are responded and collected. The analysis is done with both quantitative and qualitative techniques through descriptive research methods.

4.2.1 Distribution employees Response Analysis

I. Respondents General Information

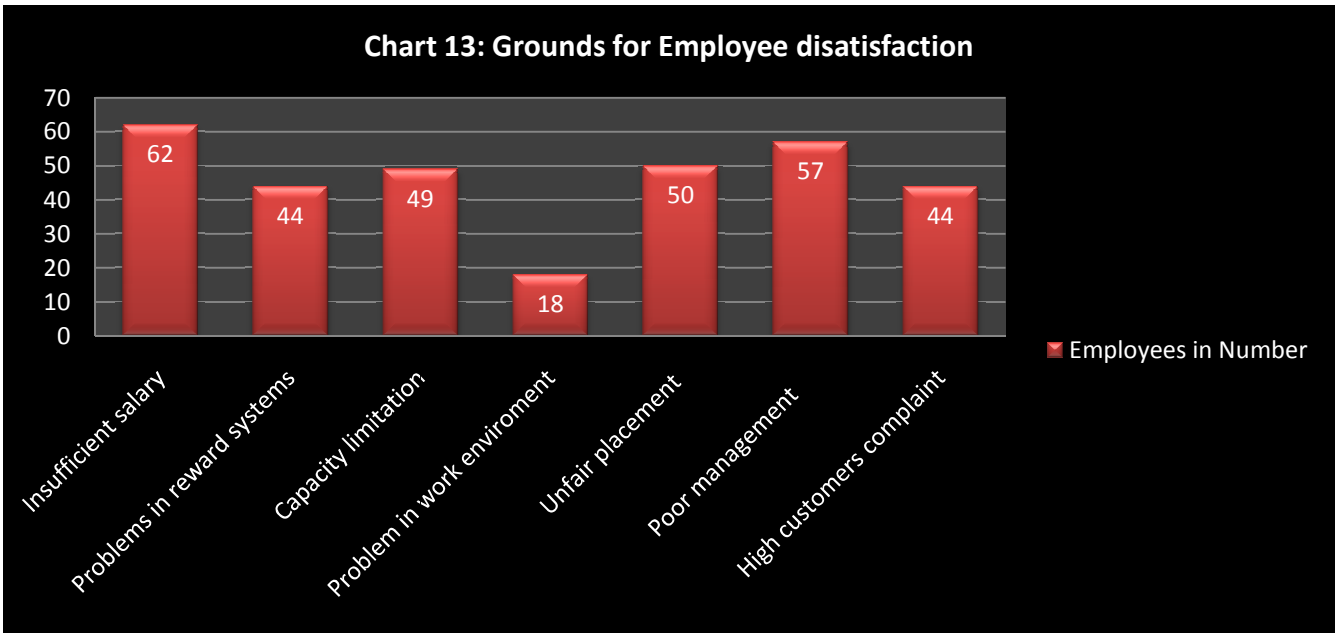
From out of the total employees who responded the question 66 employees have college diploma, 53 have bachelor degree and 21 of them grade 10/12 complete. And eight respondents have second degree and the remaining respondents are below grade ten as in indicated in chart 12.



Source: Author survey 2015

Concerning about the carrier involvements of respondents 139 (90.85%) employees are from technical areas and 14 (9.15%) respondents are from non-technical areas. Based on the responses, more than 90% of the respondents have more than two years experience and from this above 70% are more than 9 years experience.

Regarding to job satisfaction 56.21% of the respondents is dissatisfied with the current carriers. As described in chart 13 the reasons of their dissatisfactions are insufficient salary, poor management systems, high customer complaints, unfair placement, and poor performance management and reward systems, capacity limitation and working environment problems.



Source: Author survey 2015

II. Electric Service performance related responses

From one hundred sixty nine respondents one hundred fifty nine (94%) are not satisfied with the existing electric service supply of the company. The factor that contributes for the dissatisfactions of the service supply is illustrated in chart 14. As indicated in the chart a setback of electric service supply are electric power interruptions 40% of respondents; power drop 23% of respondents and poor customer service 20% of respondents. The remaining 17% of electric service supply troubles are irregular power supply, overstated and understated payments on customers' bills.

Table 1: Electric Service Supply Problem Ranks

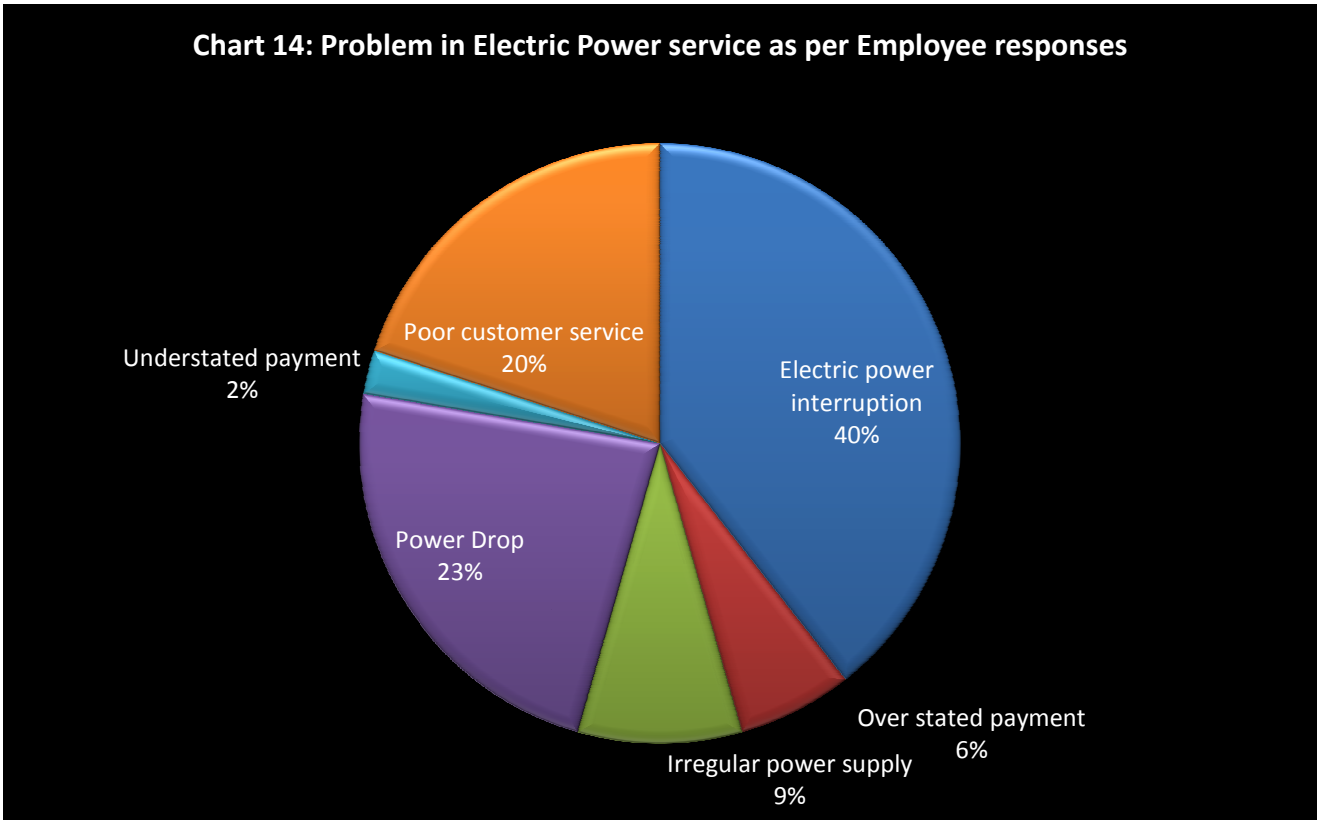
Service Problems	Assigned Ranks by Respondents						Total Points	Rank
	1	2	3	4	5	6		
Power Interruption	85	52	6	4	0	2	808	1st
Overstating Bills	0	6	6	10	58	37	237	5th
Power Reconnection	0	34	53	27	2	2	469	4th
Power Drops	45	21	25	19	14	14	574	2nd
Understating Bills	0	6	1	14	42	52	212	6th
Poor Customer Service	10	18	56	30	2	3	471	3rd

Source: Author survey 2015

N.B: The most severe ranked first and the next severe accordingly. The point is assigned as follows: Rank 1: 6 point, Rank 2: 5Point, Rank 3: 4 point, Rank 4: 3 point, Rank 5: 2 point and Rank 6: 1 point. Total points indicate the severity level of the problems; higher point implies higher severity.

According to the respondents ranking the most severe problems of electric service supply is power interruptions and power drops, poor customer service and interrupted power reconnection is the next severe problems respectively.

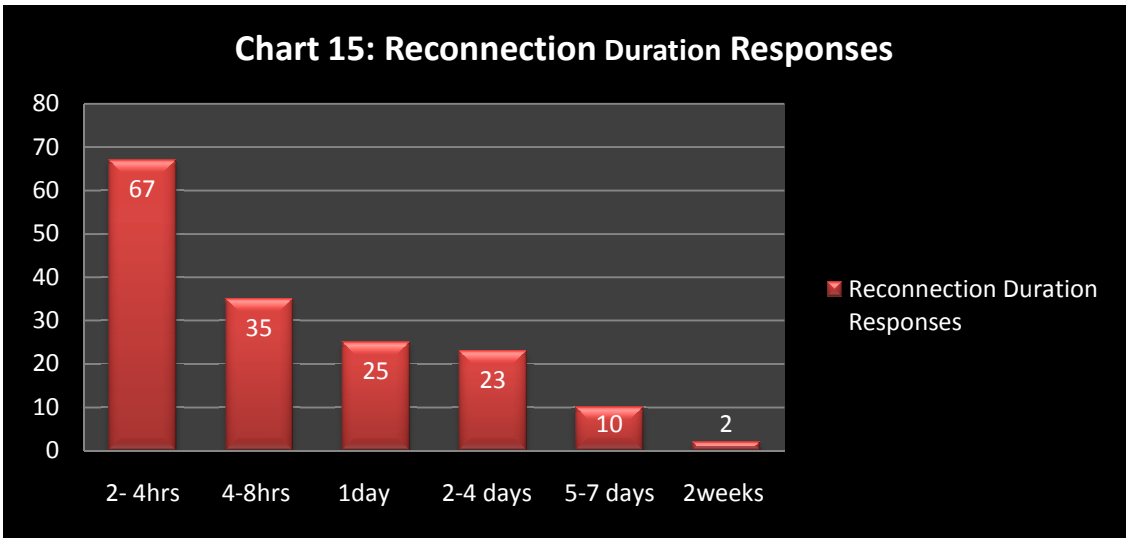
The employee also requested to evaluate the frequency of the above problems and one hundred nineteen (72%) of employees are responded that the problems are faced regularly. From the total respondents forty six (28%) employees responded that the frequency of the problem is rare. Moreover, majority of respondents answered the service provider company does not bring on time and appropriate solutions for the electric service supply problems and one hundred eleven (69%) of employees responded in favor of this.



Source: Author survey 2015

I. Interruption Duration and Reconnection Performance

Previously the customers' ranks power reconnection is the fourth severe problem of electric power supply and here they indicated about the duration of power reconnections. According to the data on chart 15 the power reconnection duration are sixty seven employees responded 2 up to 4 hours, thirty five respondents 4 up to 8 hours, and forty three respondents 1 up to 4 days and twelve respondents responded the duration takes 5 days up to two weeks.



Source: Author survey 2015

The service provider employees also rated the duration of reconnection periods, based on the responses eighty three (49%) employees rated as long interval period, fifty one (30%) employees rated as average interval and thirty four (20%) employees are rated as minimum interval period.

II. Reasons for long electric power reconnection period

Majority of respondents categorized the reconnection duration of power interruption in to long intervals periods. The response of employees reveals about the existence of many contributing factors for long duration of electric power reconnection. As per the response of employees as indicated in table 2 shortages of maintenance inputs ranked 1st contributing factors and searching of interruption areas and maintenance waiting lines ranked 2nd and 3rd respectively as a factor of contributing factors. The others factors are also ranked according to the respondents agreement levels as indicated in the table. The total points indicate that there is no significant various among contributing factors.

Table 2: Contributing Factor for long interval reconnections

Contributing Factor for long interval reconnections	Respondents Agreement levels					Total Points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Wasting of time by searching location of interrupted areas	68	49	12	20	8	620	2nd
Difficulty of tracing the fault	48	53	14	29	4	556	6th
Delay in work order	32	57	9	35	2	487	11th
Shortage of maintenance input	87	49	4	4	0	651	1st
Complexity of the maintenance	39	64	4	28	14	533	8th
Remote location of interrupted areas	36	46	12	40	0	480	12th
Long waiting line due to high rate of power interruption	47	65	11	31	0	590	3rd
Fed up of employees due to high burden & customer complaints	46	56	13	29	0	551	7th
Employees capacity limitation	41	48	13	33	8	510	10th
Shortage of maintenance staff	47	55	16	31	0	565	5th
Absence of clear work procedure	57	50	17	21	0	578	4th
Unsuitability of distribution infrastructure	35	57	13	43	0	528	9th
Ethical problems of employees	14	48	33	37	12	447	13th

Source: Author survey 2015

N.B: The most severe ranked first and the next severe accordingly. The rank point assigned as follows: Strongly Agree: 5 point, Agree: 4 Point, Neutral: 3 point, Disagree: 2 point, Strongly Disagree: 1.

III. Ethical issues in the workplace

In related to ethics ninety seven (59%) employees are responded that there are no ethical problems with in employees, in the contrary sixty seven (41%) employees responded the employees have ethical problems. The ethical problems of employees include requesting illegal payment for reconnection, concealing appropriate information about the service delivery requirements, misleading customers for illegal payment, disrespecting customers and showing offensive and unethical behavior to customers. One hundred twenty five (78%) respondents reply a few employees has ethical problems, 13.75% employees responded almost 25 % of employees have ethical problems and 8% of employees react almost 50% and more than this rate of employees has the described ethical problems.

Table 3: Ethical problems in the work Environment

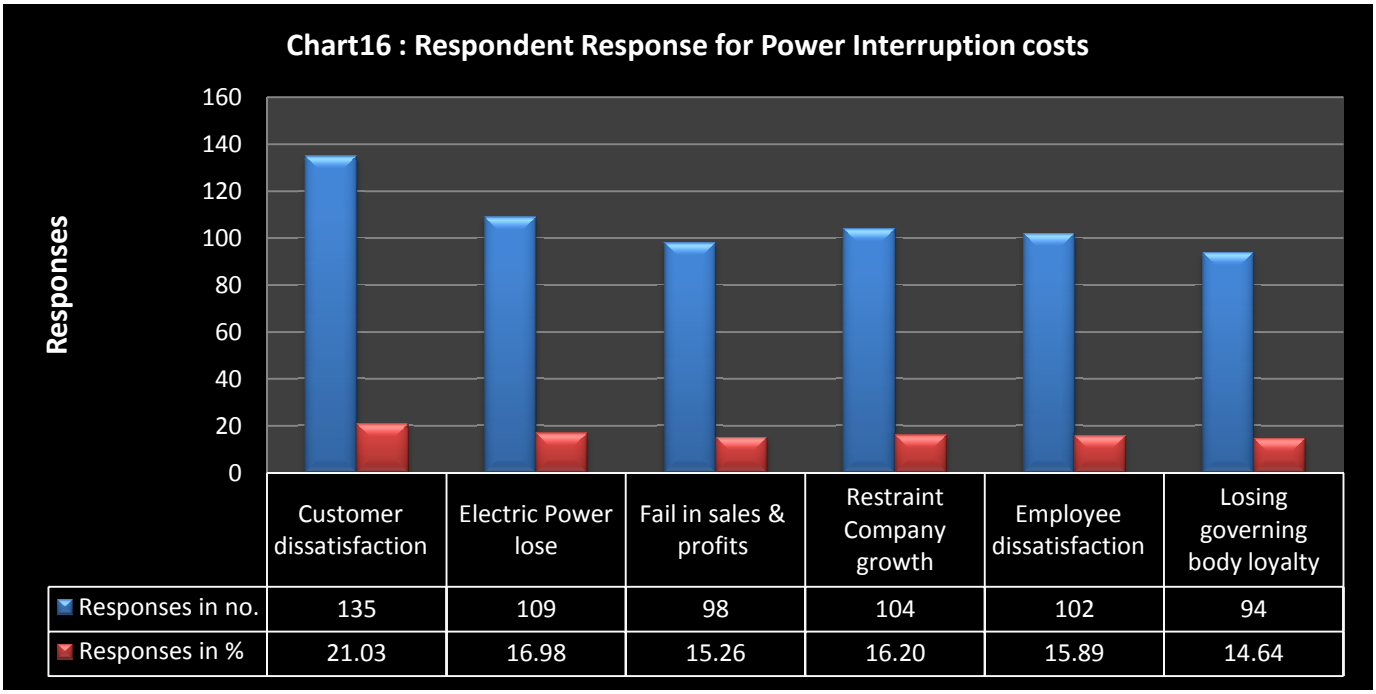
Employees ethical problem	Response in number	response in %
Demanding illegal payment for reconnection	39	22.03
Not providing appropriate information about the service delivery requirements	40	22.60
Misleading customers for illegal payment	39	22.03
Disrespecting customers	25	14.12
Show offensive and unethical behavior to customers	34	19.21
Total	177	100.00
Employees involved in unethical behavior?	Response in number	Response in %
A few employee	125	78.125
Almost 25% of employees	22	13.75
Almost 50% of employees	5	3.125
Above 50% of employees	8	5
Total	160	100

Source: Author survey 2015

IV. Effects of power interruption

Effects of power interruptions indicate the results of power supply disruption to the service provider. As indicated in chart 16 power disruption consequences to the service providers are:

- Customer dissatisfactions
- Restraint company growth
- Electric power lose
- Employee dissatisfaction
- Decrease in sales and profits
- Losing governing body loyalties

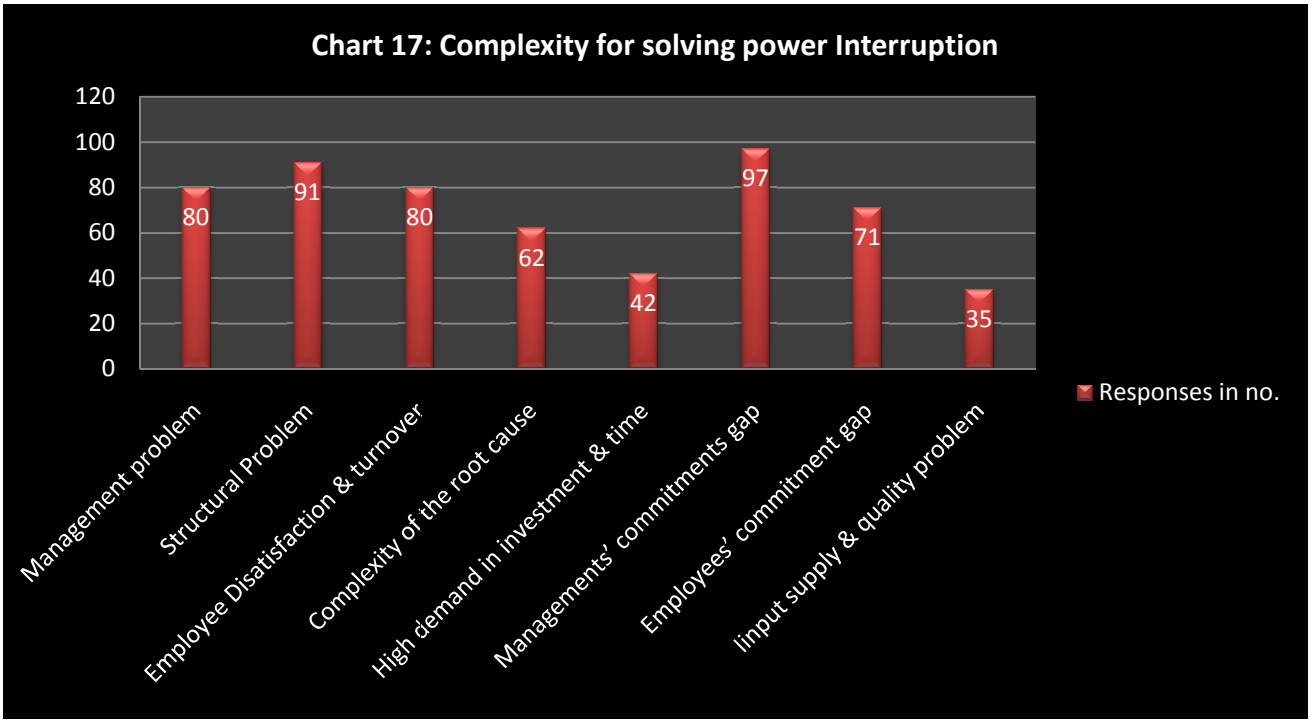


Source: Author survey 2015

V. Complexities for solving power interruption

As indicated in the above discussions power interruptions become series problems for years and the severity levels are increase year to years. Why the service provider unable to solve this problem is the basic questions needs to be answered. As indicated in chart 17 ninety seven employees responded the complexity for solving power interruptions are due to management commitment gaps, ninety one employees responded due to structural problems, eighty employees

responded due to employee dissatisfaction and turnover, the eighty employee replied due to management problems and the others reasons are demonstrated in the chart.



Source: Author survey 2015

VI. Contributing factors for power interruptions

The contributing factor implies the reason for the electric power interruption and in order to categorize according to the degree of contribution; the respondents are requested to put their agreement level. For the purpose of determining the degree of contribution of each factor the point is assigned for the agreement level from one up to five points. The allocation of the point is 5 for strongly agree, 4 for agree, 3 for neutral, 2 for disagree and 1 for strongly disagree.

Based on the response of employees agreement level evaluation, wear out of distribution infrastructures ranked in the first place and over utilization of distribution equipments & lines and absence of preventive maintenance ranked in the second and third place respectively. Those factors ranked prior places have a high degree of contribution for the electric power interruptions than proceeding ranks.

Table 4: Contributing Factors for Electric Power Interruption

Contributing Factors for Electric Power Interruption	Agreement Level					Total Points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Wear out of distribution infrastructures	103	56	2	4	0	753	1
Over utilization of distribution equipments & lines	92	56	6	6	0	714	2
Absence of preventive maintenance	76	65	8	8	0	680	3
Un expecting high development of power demand	80	52	12	18	0	680	3
Absence of performance based promotion & reward systems	89	42	15	10	0	678	4
Transformer frailer	91	45	8	8	0	675	5
Management and structural problems	75	59	10	16	0	673	6
Lose of management attention for improving distribution infrastructure	75	53	17	5	1	649	7
Poor quality of distribution materials & equipment	68	64	8	14	0	648	8
Connection of tree with distribution infrastructure	51	84	10	12	0	645	9
Deliberate disconnection for relocation for construction works	37	71	16	29	0	575	10
Deliberate disconnection for maintenance and rehabilitation purpose	29	79	20	25	0	571	11
Poor design of distribution infrastructure	40	59	31	18	0	565	12
Power theft	34	63	29	21	6	557	13
Employees skill gaps	35	72	17	13	13	553	14
Vehicle accidents on power supply infrastructure	26	73	23	29	0	549	15
Illegal power connection	32	55	29	29	6	531	16
Natural phenomenon	20	75	21	32	0	527	17
Distribution system management problems	34	51	26	33	0	518	18
Presence of corrupted employees	25	43	37	28	5	469	19

Source: Author survey 2015

VII. Priority actions should be taken for improving power interruptions

The previous responses indicate the degree of power interruption problems, contributing factors for the interruptions and its effects. And here, what prior actions should be required for improving the electric power interruption problems is analyzed. The possible priority actions are listed and the employees are requested to put their level of agreements and they put their level of agreements as demonstrated in table 5. Based on their level of agreements the priority action is ranked as indicated in the table. Rank indicates the priority of the actions, those ranked in the preceding places gets action prioritization. According to respondents agreement level responses rehabilitate the distribution infrastructures through utilization of standard quality materials obtains the first rank or priority and adequate supply of service provision inputs and automation of distribution systems ranked in the second and third places respectively.

Table 5: Prior Action for improving Electric Power Interruption

Priority Action Will be taken	Agreement Level					Total Points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Rehabilitate the distribution infrastructures by utilizing standard quality materials.	132	27	4	0	0	780	1
Adequately fulfilling service provision inputs	125	31	2	3	0	761	2
Automation of distribution systems	126	29	4	0	0	758	3
Restructuring maintenance service organization structure.	111	46	2	2	0	749	4
Establishing preventive maintenance systems	116	39	4	0	0	748	5
Minimizing distribution infrastructures from exposures of various accidents and thefts.	106	44	8	0	0	730	6
Improving human resource management practices by establishing performance based reward systems	113	31	10	2	0	723	7
Improving calling centers and create awareness about it	98	52	6	0	0	716	8
Capacity building	101	49	4	0	0	713	9
Improving service provider employee ethics	92	49	4	4	0	676	10

Source: Author survey 2015

4.2.2 Data Analysis as per Transmission Maintenance Employees responses

As per the responses of employees about the root causes of power interruptions, majority of them responded:

- Due tree branches connection with transmission lines
- Wear out of transmission and substation infrastructure
- Capacity limitation of substation
- Over capacity utilization of transmission and substation infrastructure.
- Operators capacity limitations
- Due to natural phenomena
- Structural problems
- Shortage of maintenance inputs
- Deliberate disconnection as per higher officials orders
- Over capacity demand
- Over utilization of transmission and substation infrastructure
- Absence of preventive maintenance
- Shortage of maintenance staff
- Due to theft and accident in transmission infrastructures.

I. Power Reconnection frequency & Duration

Regarding to frequency of the power interruptions, twenty four (80%) of the employees responded the interruption happened regularly and twenty (20%) employees responded the interruption has rare frequency. 60% of the employees responded that the service provider does not provide on time and appropriate solutions for the problem encountered related to electric power service and 40% of the respondents responded the company provide on time and appropriate solutions.

Table6: Interrupted Power Reconnection Period		
Reconnection interval	Respondent in number	Respondent in %
2- 4hrs	6	28.57
4-8hrs	9	42.86
1day	5	23.81
2-4 days		0.00
5-7 days	1	4.76
Total	21	100.00
Reconnection interval	Respondent in number	Respondent in %
Minimum interval	5	18.52
Average interval	11	40.74
Long interval	11	40.74
Total	27	100.00

Source: Author survey 2015

Interrupted power reconnection interval period in transmission and substation indicated in table 6, as per the response of transmission and substation maintenance employees. Based on the responses 28.57% responded the reconnection interval is 2 up to 4 hours, 42.86% of responded 4 up to 8 hours interval and 23.81% responded the reconnection duration is 1 day. As demonstrated in table 6 majorities of the respondents leveled the reconnections in to average and long intervals.

II. Contributing Factor for long interval reconnections

Power interruptions in transmission and substations affect many customers since the power supply is in high voltages or bulk power supply. According to transmission and substation employees agreement levels the contributing factors of long power reconnections durations are ranked in consideration of the degree of contributions. As demonstrated in table 7 shortage of maintenance input has highest degree of contribution and searching location of interrupted areas, absence of clear work procedure and unsuitable transmission infrastructures have the next higher degree of contribution respectively. And the other

contributing factors also ranked as per the response in the degree of contribution for long electric power reconnection durations.

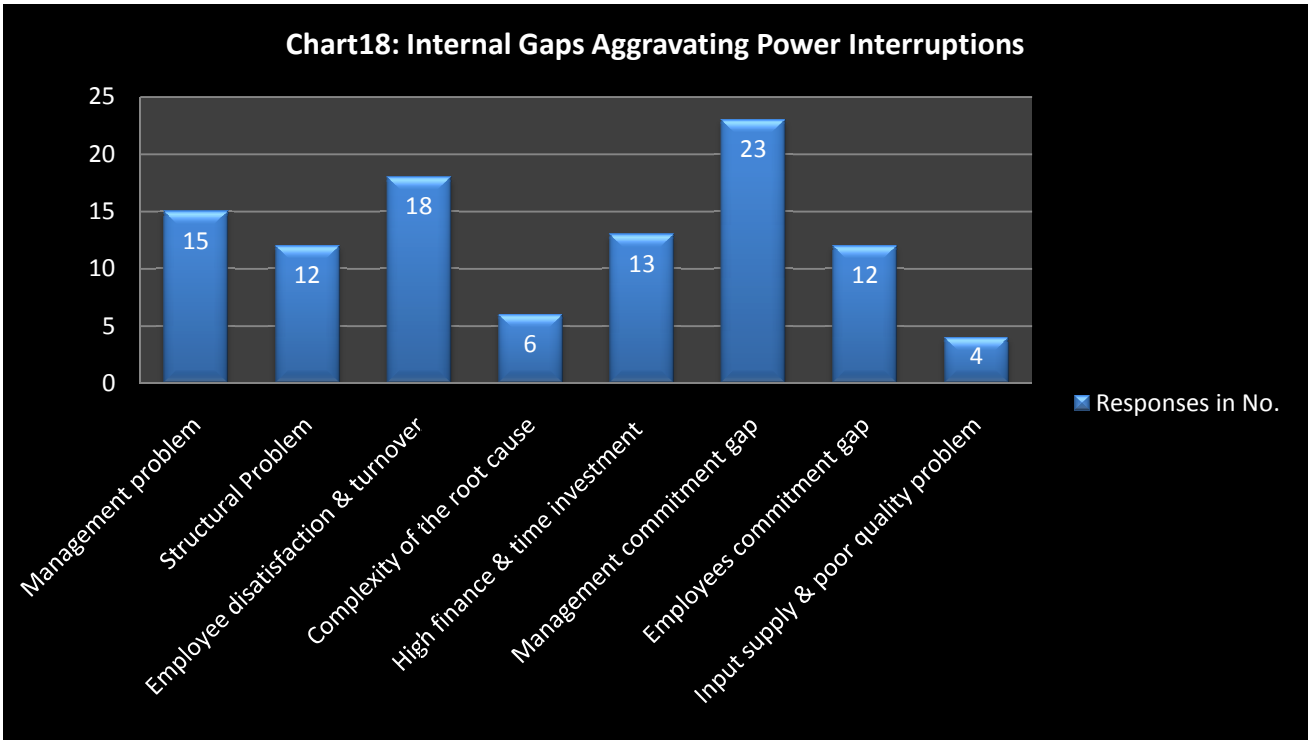
Table7: Contributing Factor for Long Interval Reconnections as Employees Response

Contributing Factor for long interval reconnections	Employees Agreement Level					Total points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Shortage of maintenance input	16	12		1		130	1
Wasting of time by searching location of interrupted areas	12	14		2		120	2
Unsuitability of transmission infrastructure	14	7	2	4	1	113	3
Absence of clear work procedure	10	9	3	6	2	109	4
Complexity of the maintenance	7	15	1	4	2	108	5
Fed up of employees due to high burden & customer complaints	8	8	3	9	5	104	6
Difficulty of tracing the fault	8	9	5	6		103	7
Delay in forwarding work order	7	8	3	13		102	8
Presence of difficult geographical location	8	10	3	5		99	9
Employees capacity limitation	9	3	5	9	6	96	10
Remote location of interrupted areas	8	8	1	7	1	90	11
Shortage of maintenance staff	4	5	2	10	3	69	12

Source: Author survey 2015

III. Internal Gaps that contributes for Power interruptions

As indicating in the chart the majority respondents responded management commitment gaps, employee dissatisfactions & employee turnover, management problems and high capital and time investment aggravating the electric power interruptions.



Source: Author survey 2015

IV. Contributing Factors for Electric Power Interruption

The cause of power interruption may varied through the grid systems, as per the reply of transmission & substation employees the contributing factors of the power interruptions in substations and transmission are wear out of substations, over utilization of substations, connection of tree with transmission infrastructure, poor quality of transmission infrastructures and transformer frailer are ranked in the first five places respectively. As indicated in table 8 the others contributing factors are ranked accordingly.

Table 8: Contributing Factor for Electric Power Interruptions as per transmission & substation employees response

Contributing Factors for Electric Power Interruption	Employees Agreement Level					Total points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Wear out of substations	21	9				141	1
Over utilization of substations	20	9				136	2
Connection of tree with transmission infrastructure	10	18	3	1		133	3
Poor quality of transmission infrastructure	14	12	3	2		131	4
Transformer frailer	18	8	1	1		127	5
Management and structural problems	15	8	6	1		127	6
Deliberate disconnection for maintenance and rehabilitation purpose	7	17	5	4		126	7
Lack of management attention for improving distribution infrastructure	15	6	3	7		122	8
Absence of performance based promotion & reward systems	14	10	2	1	1	119	9
Absence of preventive maintenance	15	9		3	1	118	10
Poor design of substation infrastructure	10	11	4	4	2	116	11
Theft on transmission infrastructure	9	15	3	1		116	12
Deliberate disconnection for relocation for construction works	9	15	2	2		115	13
Natural phenomenon	8	13	2	7	1	113	14
Transmission infrastructure management problems	13	5	4	7	1	112	15
Un expecting high development of power demand	12	9		7		110	16
Poor quality of substation infrastructure	12	11		2		108	17
Make a deliberate damage on transmission infrastructure	8	12	4	2	1	105	18
Employees skill gaps	6	3	1	16	3	80	19

Source: Author survey 2015

As per the employees responses in previous parts we understand that the power interruptions durations and frequencies are also high in transmission and substations infrastructure. The secondary data analysis also indicated the major share of power interruptions frequencies durations in non-distribution areas.

V. Priority action will be taken to improve the existing electric power interruptions

Respondents are requested to level their degree of agreement about the priority actions for the purpose of identifying the appropriate priority actions that should be taken. According to the respondents level of agreements the priority actions are ranked as illustrate in table 9. The first prioritize actions are adequately fulfilling service provision inputs and capacity building, rehabilitating substations, protecting transmission & substation infrastructure from damages and thefts are the next priority actions respectively. The other priority measures also put in order as indicated in table 9.

Table9: Contributing Factor for Long Interval Reconnections as Employees Response

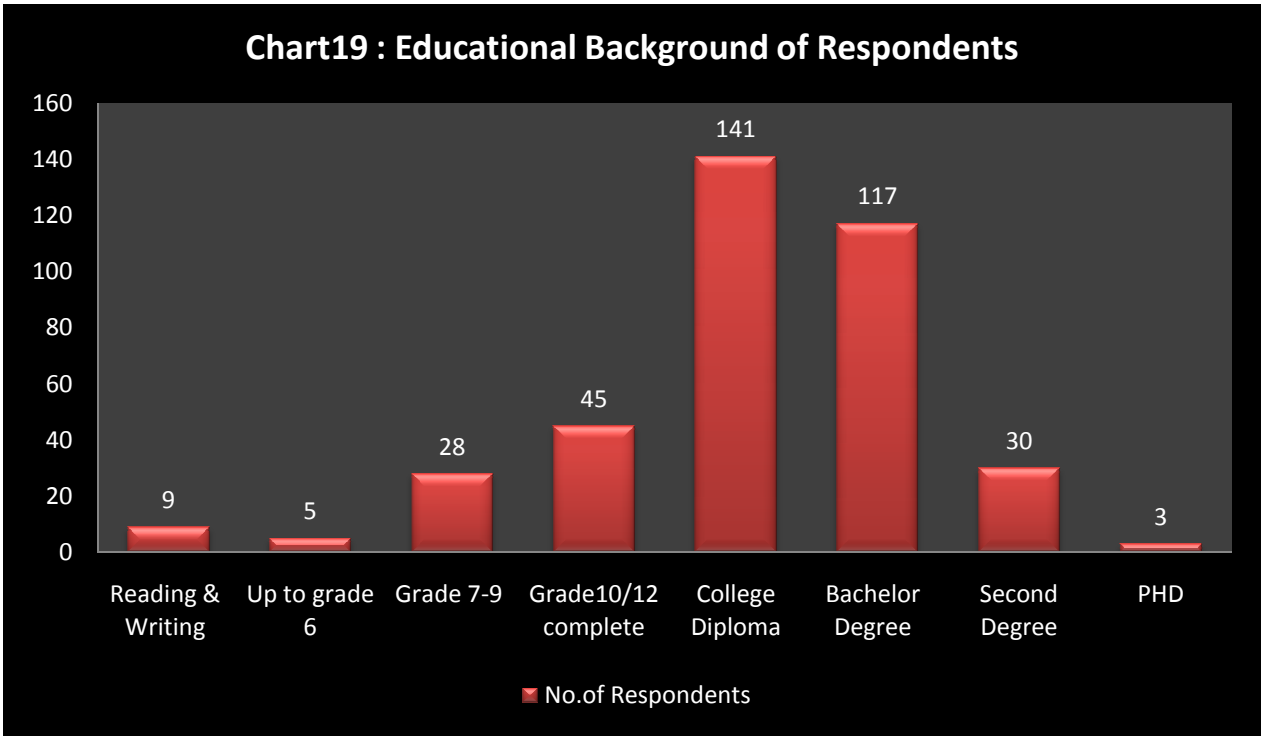
Priority Action Will be taken	Employees Agreement Level					Total points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Adequately fulfilling service provision inputs	29	4				161	1
Capacity building	25	7			1	154	2
Rehabilitate the substations.	26	3				142	3
Protecting transmission & substation infrastructure from damages and thefts.	17	13		1		139	4
Establishing preventive maintenance systems	18	11	1	1		139	5
Restructuring maintenance service organization structure.	15	13		3	1	134	6
Improving human resource management practices by establishing performance based reward systems	19	9		1	1	134	7
Automation of transmission & substation infrastructure	23	3	1	1	1	133	8
Building new substations	22	3	3	1		133	9

Source: Author survey 2015

4.2.3 Data Analysis as per customers responses

I. Respondents General Information

From the total respondents three of them have PHD, one hundred forty one have college diploma, one hundred seventeen have bachelor degree, forty five 10/12 grade complete, thirty have second degree and the remaining respondents are below grade ten as in indicated in chart 19.



Source: Author survey 2015

II. Respondents power consumption data

The consumers consume electric Power for various purposes, as indicated in table 6 the consumption frequency and varieties are enormous. We can understand from the responses that electric power consumption is growing in type and rate. They consume for entertainment, cooking, education, lighting, medication, machine operation etc….

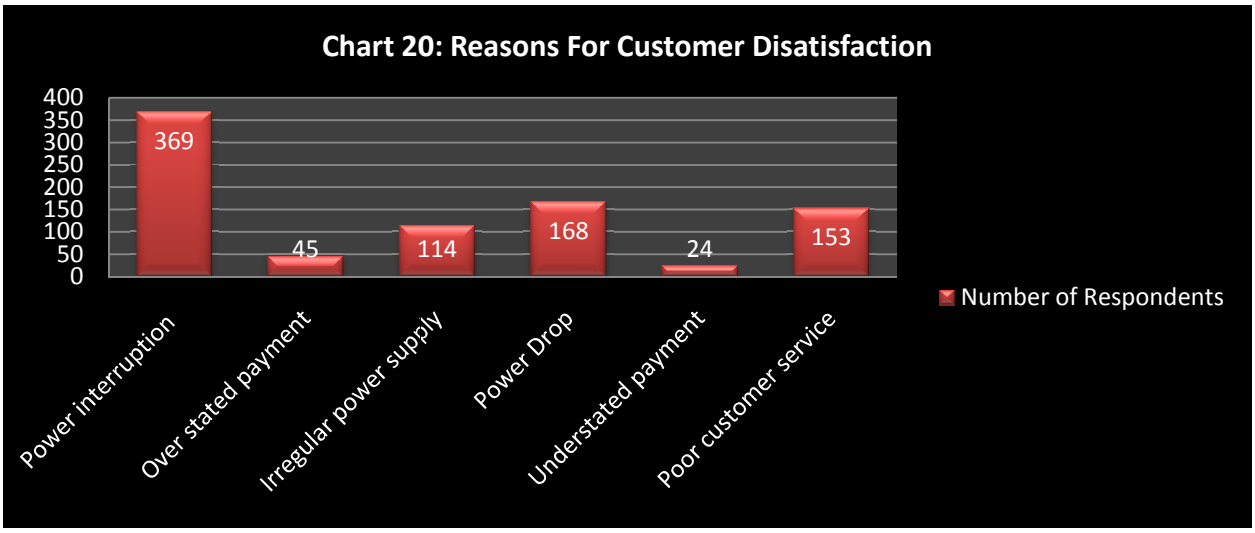
The consumption data indicates electric power becomes very vital for every human endeavor and now days it substitutes fire woods and others sources of energy.

Table 10: Users Electric Power Utilization		
Purpose of utilization	No. of Respondents	% of Respondents
Cooling	336	12.77
Heating	132	5.02
Washing	222	8.44
Refrigeration	243	9.24
Cooking	315	11.97
Lighting	366	13.91
Entertainment	249	9.46
Education	84	3.19
Television	297	11.29
Library	30	1.14
Medication	42	1.60
Computing	228	8.67
Machine Operation	87	3.31
	2631	100

Source: Author survey 2015

In regarding of power interruption two hundred forty (70.30%) respondents answered the power interruption frequency is regular and one hundred five (29.70%) responded replied that the interruption frequency is rare.

For the question asked for the satisfaction level of the existing electric service supply, three hundred sixty nine (84.25%) the respondents are reacted not satisfied with the existing service and sixty nine (15.75%) respondents are satisfied with the existing electric power supply service.



Source: Author survey 2015

From the dissatisfied customers three hundred sixty nine (42.27) respondents main reasons of the service dissatisfactions are power interruptions and one hundred sixty eight (19.24%) respondents, one hundred fifty three (17.53%) and one hundred forty (13.06%) respondents are due to power drops, poor customer service and irregular power supply respectively. The reaction of the service provider for the problems encountered in related to power supply two hundred fifty five (82.5%) respondents agreed they don't get on time and appropriate solutions but fifty four (17.45%) respondents replied they get on time and appropriate solutions.

Table 11: Electric Power Service Problems severity levels

Service Problems	**Assigned Ranks by Respondents**						Total points	Rank
	1	2	3	4	5	6		
Electric power interruption	309	48	12	12	12	3	2205	1
Overestimation in consumption	30	120	114	60	9	0	1434	2
Underestimation in consumption	39	51	69	81	36	33	1113	3
Poor customer service	21	66	84	66	36	24	1086	4
Insufficient Electric power (Power Drop)	3	45	21	36	63	36	597	5
Power reconnection problem	0	9	18	30	30	63	330	6

Source: Author survey 2015

N.B: The most severe ranked first and the next severe accordingly. The point is assigned as follows: Rank 1: 6 point, Rank 2: 5Point, Rank 3: 4 point, Rank 4: 3 point, Rank 5: 2 point and Rank 6: 1 point. Total points indicate the severity level of the problems; higher point implies higher severity.

The respondents ranking of problems are demonstrated in table 11, as per their ranking electric power interruptions are the most serious problems and overestimation in consumption, underestimation in consumption and poor customer service are the next severe problems respectively.

95% of the customers face power interruption when they are in use of it. As indicated in table 12 the frequency of power interruptions are daily for 43.57% respondents and weekly for 20.71 respondents. The durations of the interruptions are 5 up to 9 hours for 41.04% of respondents, 10 up to 14 hours for 16.42% respondents and 15 up to 19 hours for 11.19% respondents.

Table 12: Frequency and Duration of Power Interruptions

Frequency of power interruption	Respondents in no.	Respondents in %.
Daily	183	43.57
Weekly	87	20.71
At least in every 15 days	21	5.00
Monthly	21	5.00
Rarely	105	25.00
I don't notice it	3	0.71
Total	420	100.00
Duration of power interruption	Respondents in no.	Respondents in %.
1-4 hrs	99	24.63
5-9 hrs	165	41.04
10-14hrs	66	16.42
15-19 hrs	45	11.19
20-24hrs	27	6.72
Total	402	100

Source: Author survey 2015

III. Duration of Power reconnection and long interval reconnection factors.

42% of the respondents reacts the power reconnection durations are one and more days and the remaining 52% reconnection durations are eight hours and below that. As demonstrated in table 13, 72.31% of respondents level the power reconnection intervals in to long periods. Difficulty of accessing maintenance servicer call center, shortage of maintenance inputs, long maintenance waiting line and employee behavioral problem are the major four contributing factors for long interval reconnection duration.

Table13: Power reconnection duration and contributing factors for long interval reconnection		
Power Reconnection Duration	Respondents in no.	Respondents in %.
2- 4hrs	138	35.11
4-8hrs	90	22.90
1day	114	29.01
2-4 days	39	9.92
5-7 days	6	1.53
2weeks	3	0.76
3 weeks	3	0.76
Total	393	100.00
Power Reconnection Interval	Respondents in no.	Respondents in %.
Minimum interval	66	16.92
Average interval	42	10.77
Long interval	282	72.31
Total	390	100.00
Contributing factors for long interval reconnections	Respondents in no.	Respondents in %.
Inaccessibility of maintenance office call center	186	20.74
Difficulty of tracing the fault	87	9.70
Employee behavioral problem	129	14.38
Shortage of maintenance input	153	17.06
Employees' capacity problems	54	6.02
Unfeasible location of maintenance office	63	7.02
Long maintenance waiting line	138	15.38
Exhausting of employees	87	9.70
Total	897	100.00

Source: Author survey 2015

IV. Employee Ethics and Effects of power interruptions

71.5% of customers replied the service provider employees have ethical problems. As per the response significant number of the respondent replied that the major ethical problems of the service provider employees are:

- Requesting illegal payment for the service
- Concealing appropriate information of service delivery requirements.
- Misleading customers for illegal payment for the required service.
- Showing offensive and unethical behavior to customers

20.74% of respondents reacted inaccessibility of maintenance office call center, 17.06 % shortage of maintenance inputs, 15.38% Long maintenance waiting line and 14.38% Employee

behavioral problem are the contributing factors of long duration of power reconnections. 67.21 % of participants agreed a few employees have ethical problems, 13.97% of participants agreed almost 25% of employees have ethical problems and the other 13.97 agreed above 50% of the employees demonstrated unethical problems.

Table 14: Employee ethics and cost of power interruption		
Employees Ethical problems	Respondents in no.	Respondents in %.
Requesting illegal payment for the service	105	21.60
Concealing appropriate information of service delivery requirements.	99	20.37
Misleading customers for illegal payment for the required service	87	17.90
Disrespecting customers	93	19.14
Showing offensive and unethical behavior to customers	102	20.99
Total	486	
Rate of unethical employee	Respondents in no.	Respondents in %.
A few employee	246	67.21
Almost 25% of employees	51	13.93
Almost 50% of employees	18	4.92
Above 50% of employees	51	13.93
Total	366	100.00
Damages due to of electric power interruption	Respondents in no.	Respondents in %.
Spoilage of perishable goods	270	23.44
Decreasing in sales & profits	78	6.77
Disordering program	156	13.54
Extra cost for alternative power supply	204	17.71
Difficulty to pay rent fees, employee salary and tax	60	5.21
Customer dissatisfaction	96	8.33
Exposing to theft and for other related accident	72	6.25
Losing customers	42	3.65
Time and effort waste	174	15.10
Total	1152	100.00
Alternative source of energy consumed during power interruptions	Respondents in no.	Respondents in %.
Generator	69	14.47
Candle	303	63.52
Firewood	105	22.01
Total	477	100.00

Source: Author survey 2015

Power interruption exposed users for various damage and costs as indicated in table 14 majority of the participants exposed to:

- Spoilage of perishable goods
- Extra cost for alternative power supply
- Time and effort waste
- Program Disordering
- Customer dissatisfaction
- Extra cost for alternative source of power

V. Contributing factors for power interruptions as per consumer Response

The contributing factor implies the reason for the electric power interruption and in order to categorize according to the degree of contribution; the respondents are requested to put their agreement level. For the purpose of determining the degree of contribution of each factor the point is assigned for the agreement level from one up to five points. The allocation of the point is 5 for strongly agree, 4 for agree, 3 for neutral, 2 for disagree and 1 for strongly disagree.

Based on the evaluation of consumer agreement level the response transformer malfunction ranked in the first place and absence of preventive maintenance, high development of power demand, wear out of distribution infrastructures and poor quality of distribution materials & equipment placed in the subsequent rank respectively.

Table 15: Contributing Factors for Electric Power Interruption as consumer response							
Priority Action Will be taken	Agreement Level					Total Points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Transformer frailer	219	123	45	15	6	1758	1
Absence of preventive maintenance	183	165	36	18	3	1722	2
Un expecting high development of power demand	156	168	69	18	9	1704	3
Wear out of distribution infrastructures	222	99	42	12	3	1659	4
Poor quality of distribution materials & equipment	186	126	57	21	0	1647	5
Lose of management attention for improving distribution infrastructure	135	120	117	18	3	1545	6
Distribution system management problems	114	153	111	12	0	1539	7
Employees skill gaps	105	153	108	21	0	1503	8
Over utilization of distribution equipments & lines	156	120	66	15	0	1488	9
Absence of performance based promotion & reward systems	132	99	132	15	0	1482	10
Deliberate disconnection for maintenance and rehabilitation purpose	105	177	66	21	0	1473	11
Presence of corrupted employees	132	102	105	18	15	1434	12
Illegal power connection	111	111	126	24	0	1425	13
Deliberate disconnection for relocation for construction works	93	174	69	24	0	1416	14
Poor design of distribution infrastructure	81	129	132	27	3	1374	15
Connection of tree with distribution infrastructure	75	156	87	36	3	1335	16
Power theft	78	111	135	36	6	1317	17
Management and structural problems	138	84	84	18	0	1314	18
Vehicle accidents on power supply infrastructure	69	135	93	36	6	1242	19
Natural phenomenon	72	138	84	33	6	1236	20

Source: Author survey 2015

VI. Priority Measures for improving power interruptions as per consumer Response

Based on consumer responses the priority measures should be applied for improving the electric power interruption problems is analyzed as follows. The possible priority actions are listed and the consumers are put their level of agreements as demonstrated in table 8. Based on their level of agreements the priority action is ranked as indicated in the table. Rank indicates the priority the applied priority measures and those ranked in the preceding places indicates action prioritization. According to respondents agreement level responses automation of distribution systems ranked in the first place or in the first priority and rehabilitate the distribution infrastructures and adequately supplying service inputs are ranked in the second and third place accordingly.

Table 16: Priority Measures for improving Power Interruption as per consumer response

Priority Action Will be taken	Agreement Level					Total Points	Rank
	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree		
Automation of distribution systems	273	117	21	0	0	1896	1
Rehabilitate the distribution infrastructures by utilizing standard quality materials.	306	57	36	0	0	1866	2
Adequately fulfilling service provision inputs	288	99	9	0	0	1863	3
Capacity building	261	111	21	3	0	1818	4
Restructuring maintenance service organization structure.	237	123	39	6	0	1806	5
Establishing preventive maintenance systems	258	108	21	6	0	1797	6
Improving service provider employee ethics	213	120	57	0	0	1716	7
Improving calling centers and create awareness about it	231	126	15	0	0	1704	8
Minimizing distribution infrastructures from exposures of various accidents and thefts.	198	150	30	3	3	1689	9
Improving human resource management practices by establishing performance based reward systems	171	144	51	9	6	1608	10

Source: Author survey 2015

4.2.4 SWOT Analysis

The analysis is done based on the results of secondary and primary data analysis and in relation to electric power interruptions and its effects.

Strength:

- Experience in the power sector
- Capacity building in power generations

Weakness:

- Structural problems
- Power grid infrastructure management problems
- Absence of preventive maintenance
- Capacity limitations in substations and distribution lines & equipments
- Over utilization of substations and distribution lines & equipments
- Employees behavioral problems
- Managements & employees gaps
- Presence of high power interruptions, power drops and poor customer services.
- Planning gaps
- wear out of substations and distribution lines & equipments
- Shortage of input supply & quality
- Distribution and substation design problems
- Maintenance staff shortage & capacity limitations
- Technology utilization gaps in the grid systems
- Gaps in reward and performance management systems
- Power reconnection problems
- Poor distribution infrastructures

Threat:

- Natural phenomenon
- Power theft and theft in transmission infrastructures
- Deliberate and accidental damages on transmission, substations and distributions infrastructures.
- Illegal power connections

- Difficult environment and geographical locations
- High growth in power demand
- Distribution line relocations due to constructions

Opportunity:

- Government support
- Huge renewable power generation potential

4.2.5 Root cause analysis

Since the main purpose of this research project is identifying the causes of power interruptions, in this parts the root causes of the power interruptions is identified based on the primary and secondary data analysis and based interviews and author observations. The main problem of the research is power interruptions and this happened due to various reasons as discussed in the previous parts. Identifying the root causes helps for putting effective recommendation that can eliminate the cause and prevent the problem from recurring.

As indicating in chart 21 problems tree the cause effect relationships analysis is demonstrated. Based on the cause effect relationships analysis the root causes of electric power interruptions are:

A. Infrastructure capacity limitations: - The demand of electric power increases more than the capacity of substations and distribution infrastructures due to high growth in investments and constructions. Rather than quitting the power supply, the company prefers to over utilize the infrastructures and now it contributes for frequent power interruptions.

B. Poor infrastructure & Design

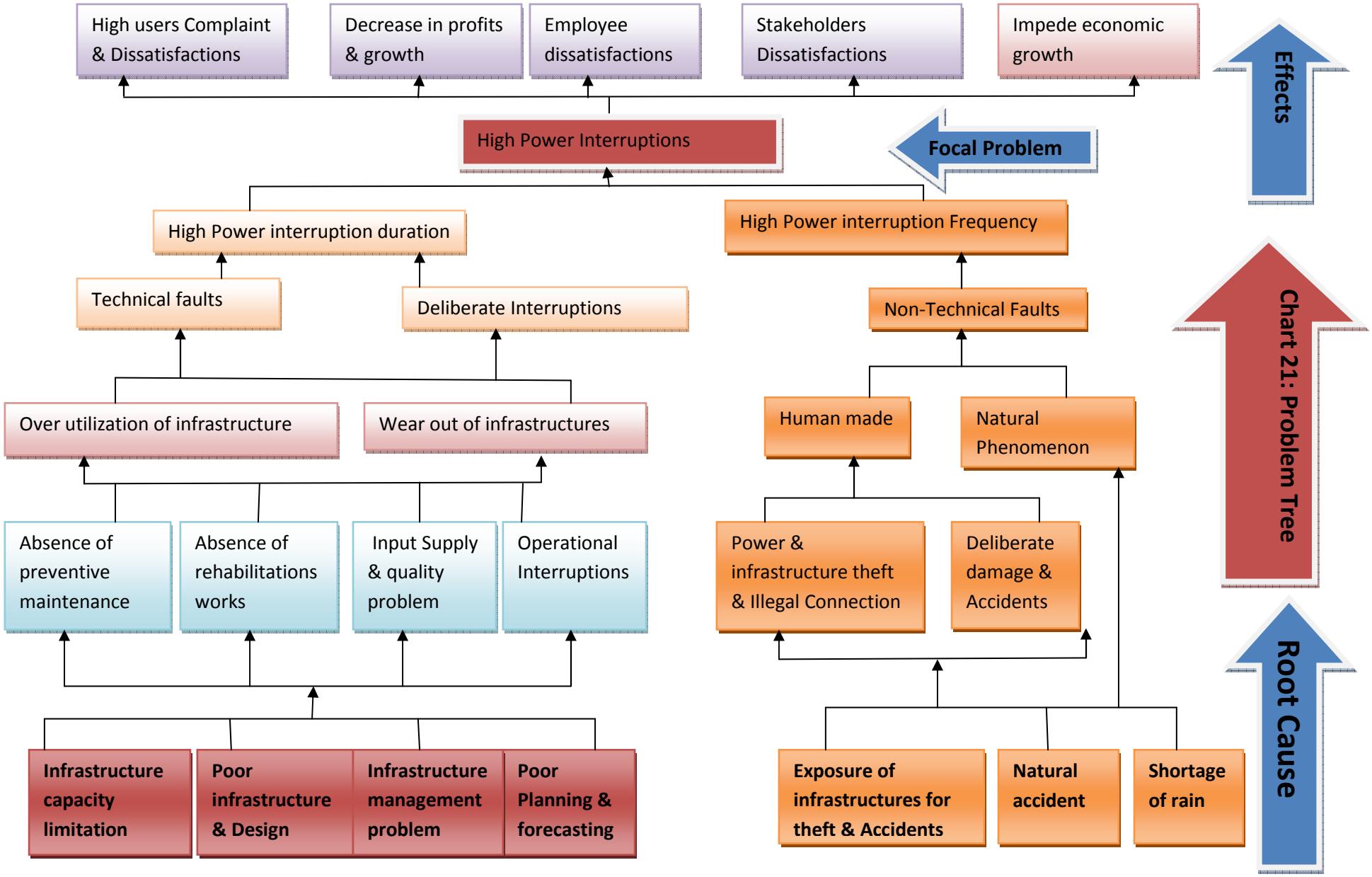
C. Infrastructure management problem

D. Poor Planning & forecasting

E. Exposure of infrastructures for theft & Accidents

F. Natural accident

G. Shortage of rain



Source: Author survey 2015

4.3 The Research Finding

The research findings bases the analysis of a four year secondary power interruptions data and the analysis of primary data that collected through questionnaire from the service provide employees and electric power consumers.

4.3.1 Findings from secondary Data Analysis

The major findings on the bases of secondary data analysis are:

- The power interruption frequency is 19,741 in 2010/11, 13617 in 2011/12, & 16,548 in 2012/13
- The duration of interruption is 20, 944 in 2010/11, 13,900 in 2011/12, and 14,758 in 2012/13
- The power interruption frequency index is 188 in 2010/11, 130 in 2011/12, and 158 in 2012/13
- The power interruption duration index is 199 in 2010/11, 132 in 2011/12, and 141 in 2012/13
- There are a high electric power interruption durations and frequencies in Addis Ababa regions than the other regions of the service provider.
- The major faults of Electric Power interruption are:-
    - Distribution permanent earth fault (DPEF)
    - Distribution permanent short circuit (DPSC)
    - Distribution transient short circuit (DTSC)
    - Distribution transient earth fault (DTEF)
    - Transmission line problem (Fault on 45, 66,132,230KV & above) (TLP)
    - System over load (SOL)
    - Generation unit problem (GUP)
    - Distribution line over load (DLOL)
    - Power transformer over load (PTOL)
    - Operational (OP).
    - Transmission line over load (TLOL).
- From this faults frequency and duration of interruption is higher in Operational (OP) (When part of the system gets Interrupted Voluntarily for Maintenance ,Load Transfer

,New Transformer Erection, commissioning etc), distribution transient earth fault (DTEF), system over load (SOL), generation unit problem (GUP), distribution permanent short circuit (DPSC)

- The power interruptions frequency and duration also increases from the year 2011/12 forwards.

4.3.2 Findings from primary Data analysis

Through analysis of service providers' employees and electric power consumers' questionnaire response the following major findings are identified:-

- 56.21% of the service provider employees are dissatisfied with the current carriers, due to insufficient salary, poor management systems, high customer complaints, unfair placement, and poor performance management and reward systems, capacity limitation and working environment problems.
- 94% of the service provider employees are not satisfied with the existing electric service supply of the company. The factor that contributes for the dissatisfactions are electric power interruptions for 40% of respondents; power drop for 23% of respondents and poor customer service for 20% of respondents.
- The duration of reconnection periods are rated by 49% employees in long interval period, and 30% employees rated in average interval.
- Shortages of maintenance inputs ranked 1st contributing factors and searching of interruption areas and maintenance waiting lines ranked in 2nd and 3rd respectively as a factor of contributing factors for long power reconnection interval.
- 41% the service provider employees agreed the employees have ethical problems. The ethical problems of employees include requesting illegal payment for reconnection, concealing appropriate information about the service delivery requirements, misleading customers for illegal payment, disrespecting customers and showing offensive and unethical behavior to customers
- Effects of power interruptions to the service providers are: Customer dissatisfactions, restraint company growth, electric power lose, employee dissatisfaction, decrease in sales and profits and losing governing body loyalties.

- Effects of power interruptions to the service providers are: Spoilage of perishable for 23.44% of respondents, extra cost for alternative power supply for 17.71% of respondents, and program disordering for 13.54% respondents
- Ninety seven employees responded the complexity for solving power interruptions are due to management commitment gaps, ninety one employees responded due to structural problems, and eighty employees responded due to employee dissatisfaction and turnover

- The root causes of the power interruptions are:
    - Wear out of distribution infrastructures
    - Over utilization of distribution equipments & lines
    - Absence of preventive maintenance
    - Absence of performance based promotion & reward systems
    - Management and structural problems
    - Poor quality of distribution materials & equipment
    - Lose of management attention for improving distribution infrastructure
    - Infrastructure capacity limitations
    - Poor infrastructure & Design
    - Infrastructure management problem
    - Poor Planning & forecasting
    - Exposure of infrastructures for theft & Accidents
    - Natural accident
    - Shortage of rain

CHAPTER FIVE: RERCOMMENDATION

5.1 Recommendation

Based on secondary data, primary data, SWOT and Problem tree analysis the following recommendation is forwarded for improving electric power interruptions and related problems:

1. **Upgrading power supply Infrastructure Capacity: -** One of the major and root causes of the power interruptions are the over utilization of substations and distribution infrastructures. This over utilizations creates overload on distribution lines, equipments and in substations and results damages in the infrastructure, power drops and for interruptions. Therefore, in order to minimize these problems the company primarily should supply the power within the capacity and for the growing and for the over capacity demand the company should upgrade its substations and distributions infrastructures
2. **Improving power infrastructure & its Design**: - The existing infrastructure and its design have great contributions for the power interruptions. The poles and distribution lines are exposed to damages and for technical and non technical power interruptions. Moreover the distribution infrastructures are difficult for fault tracing and for maintenances. The design problems are also one of the root causes of power interruptions as indicated in the primary data analysis. Thus, the company should improve power infrastructure and its designs in consideration of the future power demand and suitability for managements and maintenances and with the support of the appropriate the industry technologies.
3. **Improving Infrastructure management Practices**:- Miss to manage the electric power infrastructure exposes the infrastructures for accidents, faults, damages, thefts, illegal connections, over utilizations and for others human and natural accidents. Infrastructure management problems are as a root causes it contributes a lot for the power interruptions. For the purpose of minimizing it, the company should adapt proper infrastructure management systems. This could be practical through creations of awareness with societies and with locals' administrations bodies and through closely follow-up and check-ups and through setting technical and performance standards.
4. **Develop effective Planning & forecasting practices**: - The current high power interruptions frequencies and durations are due to over utilizations of infrastructures as a result of high growth in power demands and wear outs of the electric power infrastructures.

These comes due to overlook the future power demand and supply capacities and fail to analyze the internal and external environments as an input in planning. in planning and forecasting

5. **Establishing preventive maintenance Systems:** - The power supply are also interrupted, due to wear outs of the power infrastructure, due to tree branches and others faults. These faults could be minimized through prior measures before the power is interrupted. As indicated in the analysis part overutilization of power infrastructure and others related problems have great contributions for the existing high frequent & duration of interruptions. The company can greatly minimize these kinds of problems through establishing preventive maintenance systems.
6. **Rehabilitating power infrastructures:** -Many of the grid infrastructures are old and designed to serve the previous period's power supply, but now the supply of the power significantly increases with the limited existed infrastructures or serving in over capacity. This results for higher rate of power interruptions and for power drops. Moreover the infrastructures are not suitable for maintenance, controlling, exposed to various accidents and for thefts and not supported with the appropriate technologies. Therefore the company should rehabilitate these power infrastructures in consideration of the current problems and challenges.
7. **Supplying sufficient and quality inputs:** - Based on the findings one of the root causes of power interruptions are input quality problems and input supply shortages. These problems are one of the severe problems of the sectors. Due to these the power interruptions problems are aggravated and infrastructures are damaged and exposed for further damages as a results of shortages of protection inputs and poor quality supply. In order to minimize these problems and to improve the power supply service, the company should supply adequate and quality inputs.
8. **Minimizing Operational Interruptions**: - The four year secondary data analysis indicates there is a highest power interruption frequency and durations due to operational interruptions (When part of the system gets Interrupted Voluntarily for Maintenance, Load Transfer, New Transformer Erection, commissioning etc). Therefore, the company should minimize operational power interruptions through application of technologies that helps to

perform operational functions without interrupted the power and by applying others minimizing tools.

9. **Developing Infrastructure capacities:** - Due to the high growth of power demand more than the current power infrastructures, the company faces many challenges and problems. Capacity limitations are one of the founding bases of power interruptions and drops. Therefore, the company should develop its capacity in considerations of the current and future demands, through construction of additional substations, distribution lines and others power infrastructures.
10. **Improving human resource management Practices:** The Company should upgrade employees' capacity, should build attractive work environments, develop managements and employee commitments, establishing performance based reward and payment systems and working on improving employees ethical problems.
11. **Make further studies:** The company also will make furthers studies in order to address the problems effectively.

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APPENDIX

Questionnaires

1. For distribution & Sales Employees
2. For Transmission Employees
3. For Management body
4. For domestic customers
5. For commercial & Industrial customers

Addis Ababa University College of Business & Economics
Management Department EMBA Program

Elicit Questioners for Distribution and Sales Employees

This study is a part fulfilling the Executive Master of Business Administration (EMBA) program in Addis Ababa University. The area of the study is selected on the basis of the research result importance & coverage of existing major societal problems, in order to bring some contribution. The intention of the question is for gathering relevant data in relation to **Assessment of Power Interruptions in Addis Ababa** for the purpose of identified the root cause of power interruption and to suggest possible recommendation to policy makers and to the concerning management bodies. **Through this participation, your answers will be helpful in enhancing services provider's performance and meeting your needs. Your response will only be used for research analysis purposes and I confirm your response is confidential. Thank you very much for your time and suggestions.**

Instruction: Place an "X" mark in the box of your answer, you can mark more than one box for one question.

1. **In which educational level you are?**

☐ Reading & Writing ☐ Up to grade 6 ☐ Grade 7-9

☐ Grade10/12 complete ☐ College Diploma ☐ Bachelor Degree

☐ Second Degree ☐ PHD

2. **In which areas of responsibility you involved?**

☐ In technical areas ☐ In non-technical areas

3. **How many years of experience in the company?**

☐ **Up to 2years** ☐ **3-8 years** ☐ **9-14 years**

☐ **15-19 years** ☐ **Above 20 years**

4. **Do you satisfied with the current positions?**

☐ **Yes** ☐ **No**

5. **If you are dissatisfied with the current position, what is the major reason for your dissatisfaction?**

☐ Insufficient salary ☐ Lack of performance related reward systems
☐ Capacity limitation ☐ Presence of non- pleasant work environment
☐ Due to unfair placement ☐ Due to poor management
☐ Due to high customers complain
If any other please specify----------

6. Do you satisfied with the existing electric power service of the company?

☐ Yes ☐ No

7. If you are dissatisfied with the current electric power service, what is the major reason for the dissatisfaction?

☐ Electric power interruption ☐ Insufficient Electric power (Power Drop)
☐ Overestimation in consumption ☐ Underestimation in consumption
☐ Irregular power supply ☐ Poor customer service
☐ If any other please specify----------

8. How often do you face the above problems

☐ Regularly ☐ Rarely

9. **Does the company provider appropriate on time solution for the problem encountered related to electric power service?**

☐ Yes ☐ No

10. Rank the following electric power supply problems in accordance with the severity levels starting from 1. Rank 1 for the most severe & rank the rest accordingly.

------ Electric power interruption ------ Insufficient Electric power (Power Drop)
-------Overestimation in consumption -------Underestimation in consumption
-------Power reconnection problem -------Poor customer service

11. How long does it takes in average to reconnect interrupted electric power?

☐ 2- 4hrs ☐ 4-8hrs ☐ 1day ☐ 2-4 days
☐ 5-7 days ☐ 2weeks ☐ 3 weeks ☐ 4weeks

If any other please specify it----------

12. How would you rate the electric power reconnection time interval?

☐ Minimum interval ☐ Average interval ☐ Long interval

13. Directions: If your answer is "long interval" for question number 12, what factors contribute for that? Please indicate your level of agreement or disagreement with each of these statements regarding factors contribute for long interval reconnection. Place an "X" mark in the table of your answer.

No	Contributing Factor for long interval reconnections	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Wasting of time by searching location of interrupted areas					
2	Difficulty of tracing the fault					
3	Delay in reporting work order					
4	Shortage of maintenance input					
5	Complexity of the maintenance					
6	Remote location of interrupted areas					
7	Long waiting line due to high rate of power interruption					
8	Fed up of employees due to high burden & customer complaints					
9	Employees capacity limitation					
10	Shortage of maintenance staff					
11	Absence of clear work procedure					
12	Unsuitability of distribution infrastructure					
13	Ethical problems of employees					

14. Do you agree that some of the employees in line with the electric power supply have ethical problems?

☐ Yes ☐ No

15. If you answer "yes" for question number 14 what kind of ethical problem you experience?

☐ Demanding illegal payment for reconnection

☐ Not providing appropriate information about the service delivery requirements

☐ Misleading customers for illegal payment for quick & appropriate service delivery

☐ Disrespecting customers ☐ Offensive and showing unethical behavior to customers

If any other please specify it----------

16. How much number of employees involve in unethical behavior?

☐ A few employee ☐ Almost 25% of employees

☐ Almost 50% of employees ☐ Above 50% of employees

17. What consequences the company encountered due to electric power interruption?

☐ High customer dissatisfaction ☐ Electric Power lose

☐ Decreasing in sales & profits ☐ Restraint Company growth

☐ Employee dissatisfaction ☐ Losing governing body loyalty

I. If any other please specify it----------

18. Why the company incapable to solve the high rate of power interruption?

☐ Due to management problem ☐ Due to structural Problem

☐ Due to inability of satisfying & maintaining skilled employees

☐ Due to the complexity of the root cause ☐ Need of high investment & long time period

☐ Due to unavailability of input & poor quality materials

☐ Due to managements' commitments gap ☐ Due to employees' commitment gap

19. Directions: Please indicate your level of agreement or disagreement with each of these statements regarding factors contribute for the existing electric power interruptions. Place an "X" mark in the table of your answer.

No.	Contributing Factors for Electric Power Interruption	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Transformer frailer					
2	Wear out of distribution infrastructures					
3	Connection of tree with distribution infrastructure					
4	Poor quality of distribution materials & equipment					
5	Deliberate disconnection for relocation for construction works					
6	Deliberate disconnection for maintenance and rehabilitation purpose					
7	Distribution system management problems					
8	Vehicle accidents on power supply infrastructure					
9	Over utilization of distribution equipments & lines					
10	Natural phenomenon					
11	Presence of corrupted employees					
12	Poor design of distribution infrastructure					
13	Management and structural problems					
14	Power theft					
15	Illegal power connection					
16	Employees skill gaps					
17	Absence of preventive maintenance					
18	Un expecting high development of power demand					
19	Lose of management attention for improving distribution infrastructure					
20	Absence of performance based promotion & reward systems					

20. Is there a significant power drop problem in the existing electric power service?

☐ Yes ☐ No

21. If you answer "yes" for question number 20, what could be the basic reason for the existing power drop problem?

☐ Distribution infrastructure design problem ☐ Poor materials quality

☐ Overutilization of distribution infrastructure ☐ Power shortage

☐ Illegal power connection ☐ Power theft

If any other please specify it----------

22. When mostly do you face electric power interruption?

☐ During public holidays ☐ During Religious holidays

☐ During day time ☐ During nights

If any other please specify it----------

23. Directions: Please indicate your level of agreement or disagreement with each of these statements regarding priority action will be taken to improve the existing electric power interruptions. Place an "X" mark in the table of your answer.

No.	Priority Action Will be taken	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Rehabilitate the distribution infrastructures by utilizing standard quality materials.					
2	Capacity building					
3	Adequately fulfilling service provision inputs					
4	Automation of distribution systems					
5	Improving calling centers and create awareness about it					
6	Minimizing distribution infrastructures from exposures of various accidents and thefts.					
7	Improving service provider employee ethics					
8	Restructuring maintenance service organization structure.					
9	Establishing preventive maintenance systems					
10	Improving human resource management practices by establishing performance based reward systems					

24. If you have any idea in related to electric power interruption please write here.

What could the service provider do to solve the electric power interruption?

Thank you for sharing your thoughts!!

Addis Ababa University College of Business & Economics
Management Department EMBA Program

Elicit Questioner for Transmission & Substation Employees

This study is a part fulfilling the Executive Master of Business Administration (EMBA) program in Addis Ababa University. The area of the study is selected on the basis of the research result importance & coverage of existing major societal problems, in order to bring some contribution. The intention of the question is for gathering relevant data in relation to **Assessment of Power Interruptions in Addis Ababa** for the purpose of identified the root cause of power interruption and to suggest possible recommendation to policy makers and to the concerning management **bodies. Through this participation, your answers will be helpful in enhancing services provider's performance and meeting your needs. Your response will only be used for research analysis purposes and I confirm your response is confidential.**

Thank you very much for your time and suggestions.

Instruction: Place an "X" mark in the box of your answer, you can mark more than one box for one question.

1. **What are the root causes of power interruption in transmission lines and substations?**

   ---

2. **How often do you face the above problems**

   ☐ Regularly ☐ Rarely

3. **Does the company provider appropriate on time solution for the problem encountered related to electric power service?**

   ☐ Yes ☐ No

4. **If you answer "No" for question number 3, what are the basic reasons for that?**

---

5. **How long does it takes in average to reconnect interrupted electric power per interruption?**

☐ 2- 4hrs ☐ 4-8hrs ☐ 1day ☐ 2-4 days

☐ 5-7 days ☐ 2weeks ☐ 3 weeks ☐ 4weeks

If any other please specify it----------

6. **How would you rate the electric power reconnection time interval?**

☐ Minimum interval ☐ Average interval ☐ Long interval

7. **Directions: If your answer is "long interval" for question number 6, what factors contribute for that? Please indicate your level of agreement or disagreement with each of these statements regarding factors contribute for long interval reconnection. Place an "X" mark in the table of your answer.**

No	Contributing Factor for long interval reconnections	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Wasting of time by searching location of interrupted areas					
2	Difficulty of tracing the fault					
3	Delay in forwarding work order					
4	Shortage of maintenance input					
5	Complexity of the maintenance					
6	Remote location of interrupted areas					
7	Presence of difficult geographical location					
8	Fed up of employees due to high burden & customer complaints					
9	Employees capacity limitation					
10	Shortage of maintenance staff					
11	Absence of clear work procedure					
12	Unsuitability of transmission infrastructure					

8. Why the company incapable to solve the high rate of power interruption?

☐ Due to management problem ☐ Due to structural Problem

☐ Due to inability of satisfying & maintaining skilled employees

☐ Due to the complexity of the root cause ☐ Need of high investment & long time period

☐ Due to unavailability of input & poor quality materials

☐ Due to managements' commitments gap ☐ Due to employees' commitment gap

If any other please specify it----------

9. Directions: Please indicate your level of agreement or disagreement with each of these statements regarding factors contribute for the existing electric power interruptions. Place an "X" mark in the table of your answer.

No.	Contributing Factors for Electric Power Interruption	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Transformer frailer					
2	Wear out of substations					
3	Connection of tree with transmission infrastructure					
4	Poor quality of transmission infrastructure					
5	Deliberate disconnection for relocation for construction works					
6	Deliberate disconnection for maintenance and rehabilitation purpose					
7	Transmission infrastructure management problems					
8	Poor quality of substation infrastructure					
9	Over utilization of substations					
10	Natural phenomenon					
11	Poor design of substation infrastructure					
12	Management and structural problems					
13	Theft on transmission infrastructure					
14	Make a deliberate damage on transmission infrastructure					
15	Employees skill gaps					
16	Absence of preventive maintenance					
17	Un expecting high development of power demand					
18	Lack of management attention for improving distribution infrastructure					
19	Absence of performance based promotion & reward systems					

10. When mostly encountered electric power interruption?

☐ During public holidays ☐ During Religious holidays

☐ During day time ☐ During nights

If any other please specify it----------

11. Directions: Please indicate your level of agreement or disagreement with each of these statements regarding priority action will be taken to improve the existing electric power interruptions. Place an "X" mark in the table of your answer.

No.	Priority Action Will be taken	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Rehabilitate the substations.					
2	Capacity building					
3	Adequately fulfilling service provision inputs					
4	Automation of transmission & substation infrastructure					
5	Building new substations					
6	Minimizing transmission & substation infrastructure from damages and thefts.					
7	Restructuring maintenance service organization structure.					
8	Establishing preventive maintenance systems					
9	Improving human resource management practices by establishing performance based reward systems					

12. If you have any idea in related to electric power interruption please write here.

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13. What could the service provider do to solve the electric power interruption?

Thank you for sharing your thoughts!!

Addis Ababa University College of Business & Economics
Management Department EMBA Program

Elicit Questioners Domestic Customer

This study is a part fulfilling the Executive Master of Business Administration (EMBA) program in Addis Ababa University. The area of the study is selected on the basis of the research result importance & coverage of existing major societal problems, in order to bring some contribution. The intention of the question is for gathering relevant data in relation to **Assessment of Power Interruptions in Addis Ababa** for the purpose of identified the root cause of power interruption and to suggest possible recommendation to policy makers and to the concerning management bodies. Through this participation, your answers will be helpful in enhancing services provider's performance and meeting your needs. Your response will only be used for research analysis purposes and I confirm your response is confidential. Thank you very much for your time and suggestions.

Instruction: Place an "X" mark in the box of your answer, you can mark more than one box for one question.

1. In which educational level you are?

☐ Reading & Writing ☐ Up to grade 6 ☐ Grade 7-9
☐ Grade10/12 complete ☐ College Diploma ☐ Bachelor Degree
☐ Second Degree ☐ PHD

2. For what purpose you consume electric power? Place an "X" mark in the table of your answer.

No.	Possible Electric Services	Electric Consumption	No	Electric Consumption	Possible Electric Services
1	Cooling		8	Education	
2	Heating		9	Television	
3	Washing		10	Library	
4	Refrigeration		11	Medication	
5	Cooking		12	Computing	
6	Lighting		13	Machine Operation	
7	Entertainment		14	Furnaces	

Specify if you use for any other purpose----------

3. **How much you averagely expense for electric power consumption per monthly?** Birr___
4. **Do you satisfied with the existing electric power service?**

   ☐ Yes ☐ No
5. **If you are dissatisfied with the current electric power service, what is the major reason for your dissatisfaction?**

   ☐ Electric power interruption ☐ Insufficient Electric power (Power Drop)

   ☐ Overestimation in consumption ☐ Underestimation in consumption

   ☐ Irregular power supply ☐ Poor customer service

   If any other please specify it----------
6. **How often do you face the problem you mentioned in question no.5 above problems**

   ☐ Regularly ☐ Rarely
7. **Do you get a proper and on time solutions from the service provider for the problem encountered related to service?**

   ☐ Yes ☐ No
8. **Rank the following electric power supply problems in accordance with the severity levels you faced starting from 1. Rank 1 for the most severe & rank the rest accordingly.**

   ------ Electric power interruption ------ Insufficient Electric power (Power Drop)

   -------Overestimation in consumption -------Underestimation in consumption

   -------Power reconnection problem -------Poor customer service
9. **Do you face electric power interruption during you use the service?**

   ☐ Yes ☐ No
10. **If you say "yes" for question number 8, how often do you face the power interruption?**

    ☐ Daily ☐ Weekly ☐ At least in every 15 days

    ☐ Monthly ☐ Rarely ☐ I don't notice it

    If any other please specify----------
11. **How long do you use electric power per day in average?**

    ☐ 1-4 hrs ☐ 5-9 hrs ☐ 10-14hrs

    ☐ 15-19 hrs ☐ 20-24hrs
12. **For how long you lose electric power in average per month ----------hrs?**

13. How long do you wait to reconnect the interrupted electric power in average per interruption?

☐ 2- 4hrs ☐ 4-8hrs ☐ 1day ☐ 2-4 days

☐ 5-7 days ☐ 2weeks ☐ 3 weeks ☐ 4weeks

If any other please specify it----------

14. How would you rate the electric power reconnection time interval?

☐ Minimum interval ☐ Average interval ☐ Long interval

15. If your answer is "long time interval" for question number 14, what factors contribute for long interval reconnections?

☐ Inaccessibility of service provider call center ☐ Difficulty of tracing the fault

☐ Behavioral problems of service provider employees ☐ Shortage of maintenance input

☐ Employees' capacity problems ☐ Remote location of service provider

☐ Long waiting line due to high rate of power interruption ☐ Fed up of employees

If any other please specify it----------

16. Do you agree that the service provider employees have ethical problems?

☐ Yes ☐ No

17. If you answer "yes" for question number 16 what kind of ethical problem you experience?

☐ Demanding illegal payment for reconnection

☐ Not providing appropriate information about the service delivery requirements

☐ Misleading customers for illegal payment for quick & appropriate service delivery

☐ Disrespecting customers ☐ Offensive and showing unethical behavior to customers

If any other please specify it----------

18. Where do you level the number of employees that involve in unethical behavior?

☐ A few employee ☐ Almost 25% of employees

☐ Almost 50% of employees ☐ Above 50% of employees

19. What damage do you face due to electric power interruption?

☐ Spoilage of perishable goods ☐ Customer dissatisfaction

☐ Decreasing in sales & profits ☐ Exposing to theft and for other related accident

☐ Disordering program ☐ Losing customers

☐ Extra cost for alternative power supply. ☐ Time and effort waste

☐ Difficulty to pay rent fees, employee salary and tax

If any other please specify it----------

20. What alternative source of energy you consume during electric power interruptions

☐ Generator ☐ Candle ☐ Firewood

If you use other please specify it----------

21. **How much extra cost in average do you incur per month due to electric power interruption? ----------**

22. **Directions: Please indicate your level of agreement or disagreement with each of these statements regarding factors contribute for the existing high power interruptions. Place an "X" mark in the table of your answer.**

No.	Contributing Factors for Electric Power Interruption	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Transformer frailer					
2	Wear out of distribution infrastructures					
3	Connection of tree with distribution infrastructure					
4	Poor quality of distribution materials & equipment					
5	Deliberate disconnection for relocation for construction works					
6	Deliberate disconnection for maintenance and rehabilitation purpose					
7	Distribution system management problems					
8	Vehicle accidents on power supply infrastructure					
9	Over utilization of distribution equipments & lines					
10	Natural phenomenon					
11	Presence of corrupted employees					
12	Poor design of distribution infrastructure					
13	Management and structural problems					
14	Power theft					
15	Illegal power connection					
16	Employees skill gaps					
17	Absence of preventive maintenance					
18	Un expecting high development of power demand					
19	Lose of management attention for improving distribution infrastructure					
20	Absence of performance based promotion & reward systems					

23. **Do you experience irregular electric power supply?**

☐ Yes ☐ No

24. **If you answer "yes" for question number 23, how often it happened?**

☐ Rarely ☐ Regularly

25. **Do you exposed for house equipment damaged due to irregular electric power supply?**

☐ Yes ☐ No

26. Do you have a power drop in your areas?

☐ Yes ☐ No

27. When mostly do you face electric power interruption?

☐ During public holidays ☐ During Religious holidays

☐ During day time ☐ During nights

If any other please specify it----------

28. Directions: Please indicate your level of agreement or disagreement with each of these statements regarding priority actions will be taken for improving the existing electric power interruptions problems. Place an "X" mark in the table of your answer.

No.	Priority Action Will be taken	Strongly Agree	Agree	Neutral	Strongly Disagree
1	Rehabilitate the distribution infrastructures by utilizing standard quality materials.				
2	Capacity building				
3	Adequately fulfilling service provision inputs				
4	Automation of distribution systems				
5	Improving calling centers and create awareness about it				
6	Minimizing distribution infrastructures from exposures of various accidents and thefts.				
7	Improving service provider employee ethics				
8	Restructuring maintenance service organization structure.				
9	Establishing preventive maintenance systems				
10	Improving human resource management practices by establishing performance based reward systems				

29. If you have any idea in related to electric power interruption please write here.

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30. What could the service provider do to solve the electric power interruption?

Thank you for sharing your thoughts

Addis Ababa University College of Business & Economics
Management Department EMBA Program

Elicit Questioners for Commercial & Industrial Customer

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Instruction: Place an "X" mark in the box of your answer, you can mark more than one box for one question.

1. **In which educational level you are?**

☐ Read & Writing ☐ Up to grade 6 ☐ Grade 7-9
☐ Grade10/12 complete ☐ College Diploma ☐ Bachelor Degree
☐ Second Degree ☐ PHD

2. **In which business sector you involved?**_____
3. **For what purpose you consume electric power? Place an "X" mark in the table of your answer.**

No.	Possible Electric Services	Electric Consumption	No	Electric Consumption	Possible Electric Services
1	Cooling		8	Education	
2	Heating		9	Television	
3	Washing		10	Library	
4	Refrigeration		11	Medication	
5	Cooking		12	Computing	
6	Lighting		13	Machine Operation	
7	Entertainment		14	Furnaces	

Specify it if you use for any other purpose----------

4. **How much you averagely expense for electric power consumption per monthly?** Birr___
5. **Do you satisfied with the existing electric power service?**

   ☐ Yes ☐ No
6. **If you are dissatisfied with the current electric power service, what is the major reason for your dissatisfaction?**

   ☐ Electric power interruption ☐ Insufficient Electric power (Power Drop)

   ☐ Overestimation in consumption ☐ Underestimation in consumption

   ☐ Irregular power supply ☐ Poor customer service

   If any other please specify it----------
7. **How often do you face the problem you mentioned in question no.6 above problems**

   ☐ Regularly ☐ Rarely
8. **Do you get a proper and on time solutions from the service provider for the problem encountered related to service?**

   ☐ Yes ☐ No
9. **Rank the following electric power supply problems in accordance with the severity levels you faced starting from 1. Rank 1 for the most severe & rank the rest accordingly.**

   ------ Electric power interruption ------ Insufficient Electric power (Power Drop)

   -------Overestimation in consumption -------Underestimation in consumption

   -------Power reconnection problem -------Poor customer service
10. **Do you face electric power interruption during you use the service?**

    ☐ Yes ☐ No
11. **If you say "yes" for question number 10, how often do you face the power interruption?**

    ☐ Daily ☐ Weekly ☐ At least in every 15 days

    ☐ Monthly ☐ Rarely ☐ I don't notice it

    If any other please specify----------
12. **How long do you use electric power per day in average?**

    ☐ 1-4 hrs ☐ 5-9 hrs ☐ 10-14hrs

    ☐ 15-19 hrs ☐ 20-24hrs
13. **For how long you lose electric power in average per month ----------hrs?**

14. How long do you wait to reconnect the interrupted electric power in average per interruption?

☐ 2- 4hrs ☐ 4-8hrs ☐ 1day ☐ 2-4 days

☐ 5-7 days ☐ 2weeks ☐ 3 weeks ☐ 4weeks

If any other please specify it----------

15. How would you rate the electric power reconnection time interval?

☐ Minimum interval ☐ Average interval ☐ Long interval

16. If your answer is "long time interval" for question number 15, what factors contribute for long interval reconnections?

☐ Inaccessibility of service provider call center ☐ Difficulty of tracing the fault

☐ Behavioral problems of service provider employees ☐ Shortage of maintenance input

☐ Employees' capacity problems ☐ Remote location of service provider

☐ Long waiting line due to high rate of power interruption ☐ Fed up of employees

If any other please specify it----------

17. Do you agree that the service provider employees have ethical problems?

☐ Yes ☐ No

18. If you answer "yes" for question number 17 what kind of ethical problem you experience?

☐ Demanding illegal payment for reconnection

☐ Not providing appropriate information about the service delivery requirements

☐ Misleading customers for illegal payment for quick & appropriate service delivery

☐ Disrespecting customers ☐ Offensive and showing unethical behavior to customers

If any other please specify it----------

19. Where do you level the number of employees that involve in unethical behavior?

☐ A few employee ☐ Almost 25% of employees

☐ Almost 50% of employees ☐ Above 50% of employees

20. What damage do you face due to electric power interruption?

☐ Spoilage of perishable goods ☐ Customer dissatisfaction

☐ Decreasing in sales & profits ☐ Exposing to theft and for other related accident

☐ Disordering program ☐ Losing customers

☐ Extra cost for alternative power supply. ☐ Time and effort waste

☐ Difficulty to pay rent fees, employee salary and tax

If any other please specify it----------

21. What alternative source of energy you consume during electric power interruptions

☐ Generator ☐ Candle ☐ Firewood

If you use other please specify it----------

22. **How much extra cost in average do you incur per month due to electric power interruption? ----------**

23. **Directions: Please indicate your level of agreement or disagreement with each of these statements regarding factors contribute for the existing high power interruptions. Place an "X" mark in the table of your answer.**

No.	Contributing Factors for Electric Power Interruption	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Transformer frailer					
2	Wear out of distribution infrastructures					
3	Connection of tree with distribution infrastructure					
4	Poor quality of distribution materials & equipment					
5	Deliberate disconnection for relocation for construction works					
6	Deliberate disconnection for maintenance and rehabilitation purpose					
7	Distribution system management problems					
8	Vehicle accidents on power supply infrastructure					
9	Over utilization of distribution equipments & lines					
10	Natural phenomenon					
11	Presence of corrupted employees					
12	Poor design of distribution infrastructure					
13	Management and structural problems					
14	Power theft					
15	Illegal power connection					
16	Employees skill gaps					
17	Absence of preventive maintenance					
18	Un expecting high development of power demand					
19	Lose of management attention for improving distribution infrastructure					
20	Absence of performance based promotion & reward systems					

24. **Do you experience irregular electric power supply?**

☐ Yes ☐ No

25. **If you answer "yes" for question number 23, how often it happened?**

☐ Rarely ☐ Regularly

26. Do you exposed for house equipment damaged due to irregular electric power supply?

☐ Yes ☐ No

27. Do you have a power drop in your areas?

☐ Yes ☐ No

28. When mostly do you face electric power interruption?

☐ During public holidays ☐ During Religious holidays

☐ During day time ☐ During nights

If any other please specify it----------

29. Directions: Please indicate your level of agreement or disagreement with each of these statements regarding priority actions for improving the existing electric power interruptions problems. Place an "X" mark in the table of your answer.

No.	Priority Action Will be Taken	Strongly Agree	Agree	Neutral	Strongly Disagree
1	Rehabilitate the distribution infrastructures by utilizing standard quality materials.				
2	Capacity building				
3	Adequately fulfilling service provision inputs				
4	Automation of distribution systems				
5	Improving calling centers and create awareness about it				
6	Minimizing distribution infrastructures from exposures of various accidents and thefts.				
7	Improving service provider employee ethics				
8	Restructuring maintenance service organization structure.				
9	Establishing preventive maintenance systems				
10	Improving human resource management practices by establishing performance based reward systems				

30. If you have any idea in related to electric power interruption please write here.

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31. What could the service provider do to solve the electric power interruption?

Thank you for sharing your thoughts!!

Addis Ababa University College of Business & Economics
Management Department EMBA Program

Elicit Questioner for Management body

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Thank you very much for your time and suggestions.

1. **How do you evaluate the overall electric power service supply performance of the company?**

   ---

2. **What are the current major challenge of the company?**

   ---

3. **Do you agree or disagree with the point " the company has high customer complaints". Why?**

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4. **What are the foremost reasons of the existing electric power interruption in your process?**

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5. **What the company intends to solve the power interruption problems?**

Thank you for sharing your thoughts!!