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EVALUATING COST OF POWER OUTAGES AND PRODUCTION þÿ I N T E R U P T I O N S O N E T H I O P I A CEMENT INDUSTRIES

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EVALUATING COST OF POWER OUTAGES AND PRODUCTION INTERUPTIONS ON ETHIOPIA'S CEMENT INDUSTRIES

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EVALUATING COST OF POWER OUTAGES AND PRODUCTION INTERUPTIONS ON ETHIOPIAS CEMENT INDUSTRIES

BY: TAMRAT BIRMETA

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Industrial Management

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Approval of Thesis for defense

I hereby certify that I have supervised, read, and evaluated this thesis titled **"Evaluating cost of Power outages and production Interruptions on Ethiopia's cement Industries"** prepared by TAMRAT BIRMETA under my guidance. I recommend the thesis to be submitted for oral defense.

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Approval of thesis for defense result

I hereby confirm that the changes required by the examiners have been carried out and incorporated in the final thesis.

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As members of the board of examiners, we examined this thesis entitled "EVALUATING COST OF POWER OUTAGES AND PRODUCTION INTERUPTIONS ON ETHIOPIAS CEMENT INDUSTRIES" by Tamrat Birmeta. We hereby certify that this the thesis is accepted for fulfilling the requirements for the award of degree of Master of Science in Industrial Management

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Tamrat Birmeta	________________________	_____________
Name of the student:	Signature	Date

This Thesis is dedicated to my mother the late **Tsige Birbo** who I lost last year, who raised me to be the person I am today, who passed through so many sufferings uncomfortable and restless day and nights to raise me and my brothers and sister

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ABSTRACT

Power interruptions, outages and load shading are some of the challenges the manufacturing industries in Ethiopia facing. In this paper the impact of power outages in selected cement plants in Ethiopia is studied. The methodology employed in this paper are Direct output loss and other losses using company‘s four years data (2016 to 2019) record data and Indirect method using willingness to pay by choice experiment method to measure the cost imposed by power outages. Estimating the true opportunity costs to the enterprises using decision matrix from lost production caused by power outages is used in determination of the feasibility of mitigating measures.

Based on the findings all the variables studied like frequency of outage, duration of outage and type of outage are found to have significant impact on the companies productivity and profitability and they are willing to pay extra to minimize the power interruption and duration.

The result of the study shows that the five companies lost 5,547 hrs of operation due to power loss and it is estimated to be a total of 90 million birr due to idle manpower over the course of four years and also their labor productivity only by power interruption went down on average by 3.5% and a total of 1 million ton of cement is not supplied to the market. When it comes to willingness to pay the companies are willing to pay 1.07% additional cost for a reduction of frequency of outage by 1 and willing to pay 13.3% more for a reduction of the duration by 1hr. and 0.5% more payment for a prior notification before the outages.

Keywords: Choice experiment, Power outage, Willingness to pay, Conditional Logit, Loss

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LIST OF ABREVIATIONS

CE Choice Experiment

DCE Discrete Choice Experiment

EEP Ethiopian Electric Power

EEU Ethiopian Electric Utility

GTP Growth and Transformation Plan

KWh Kilo watt hour

ML mixed logit model.

MW Mega Watt

OPC Ordinary Portland cement (OPC)

OPEC Organization of the Petroleum Exporting Countries

PPC Portland Pozzolana Cement (PPC)

RPL Random parameter logit

USAID United States Agency for International Development

VOLL Value of Lost Load

WTP Willingness to Pay

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CHAPTER ONE

1. INTRODUCTION

1.1 Background

In addition to air and water, energy is one of the basic elements necessary for human survival, and today a reliable supply of energy is the backbone of any countries economy. Although reliable power supply is critical to any economy, there are still problems with power supply and reliability, especially in low-income countries where the percentage of power failure is high.

According to Simonoff et al. (2005) many factors can cause power outages: crime, equipment failure, fire, human error, operation error, natural disaster, weather, lack of capacity, etc. However, for many developing countries, including Ethiopia; power shortage leading to load shedding and equipment failure is the number one reason for power outages.

Any country, including Ethiopia, is highly dependent on energy. According to Alam (2006), ―energy is an indispensable force to promote all economic activities‖. This means that the higher the energy consumption, the greater the economic activities of the country, which reflects the growth of an economy. The ability of a country to fully develop and effectively manage its available resources to achieve economic development is related to energy access, reliability and efficiency.

Prior to evaluate electric power reliability, business productivity, and economic growth, we must understand the factors that affect customers, and we must also understand the cost of outages. The duration of the interruption, the nature of the interruption (unexpected or planned), the length of time the interruption occurred (during working hours or outside working hours, actually this factor does not apply as cement plants are operated for 24 hours), and the season (summer or winter). On the other hand, when proposing the evaluation techniques, the type of customer (industrial, service, residential or agricultural) seems to be the most critical factor. The most important parameter is the type of customer. Large-scale industrial and commercial facilities are increasingly dependent on electrical and electronic equipment, making these facilities more dependent on the reliability and quality of power provided by power companies.

Manufacturing is one of the sectors of economic activity in a country, it is an aspect of the economy that is dedicated to the production of goods by transforming raw materials in the production process. A study by Yahaya, Salisu, and Uma (2015) concluded that for any economy to achieve sustainable growth, it must have a strong manufacturing industry. In a modern economy where the industrialization process is accelerating and domestic consumption and exports require large-scale production, electricity is considered the main factor that promotes the efficiency and productivity of other factors of production (especially labor and capital.

The construction industry is given a particular attention in the policies of many developing countries. The Ethiopian government also has invested millions of dollars in social housing, which is unprecedented opportunity for contractors, and the construction industry is currently the largest employer in the country, with more than 2 million people in temporary and fulltime jobs according to 2019 report from the Ministry of Construction. However, the construction industry faces many challenges, from increasing debt to difficulty in obtaining the right materials at the right price. One of the inputs of the construction industry is cement. Insufficient supply of cement and high prices put contractors, investors, governments, the public and other stakeholders into trouble due to project delays and high project costs. Ethiopia has experienced chronic cement supply shortages many times in different periods, but due to the lack of water in hydroelectric dams this problem was even got more serious as the country starts electricity rationing in 2019. Although the reasons for the shortage of cement vary, one of the reasons is that the country‘s power interruption and power shading have caused supply delays, making it difficult for cement plants to meet market demand.

In Ethiopia, due to its fundamental role in overall economic development, the cement industry has been identified as one of the first and second Growth and Transformation Plan (GTP) areas as a special consideration sector.

Although some economists believe that energy is an intermediate input in production and promotes production factors, (Alam, 2006) however argues that energy is a major input in production. Beaudreau (2005) believes that the transformation of steam, fossil fuel, and hydraulic power sources into a more usable form of energy such as electricity as a way forward for a greater increase in speed, efficiency, and consequently, productivity. The increase in power consumption in the manufacturing industry indicates an increase in the operating speed of the manufacturing process, which ultimately leads to an increase in output. Therefore, if higher output is to be achieved, the relationship between electricity and production in the machine-driven industry cannot be ignored.

Improving the accessibility and quality of electricity services can improve sustainable economic development and social well-being, while at the same time creating more revenue for the government and manufacturing sector players, and contributing to the further development of the energy sector. But policy makers need information about the impact of electricity service cuts off and the benefits of providing reliable electricity supply in the economy.

A number of studies conducted in developed countries and points out the importance of sustainable power supply for manufacturing industries, most developing countries in general and Ethiopia in particular has failed to assess the extent of the impact and design a way to tackle the impact. This study examines the impact of unreliable power supply on selected cement industries in Ethiopia and the companies willingness to pay (WTP) to avoid unannounced power interruptions. The study applied the Choice Experiment (CE) method to provide new evidence about the demand for improved electricity in the context of Ethiopia, using the electricity service's characteristics to value reliability.

1.1.1 Cement manufacturing process

Cement is a fine powder that is used as a hydraulic binder in construction projects. It sets, harden and adhere to other materials to bond them. A cement plant is a place where raw materials are converted into cement through various technologies and processes. (M. Schneider, M. Romer, M. Tschudin, and H. Bolio, 2011)

The cement plant is custom-designed according to the location and is a long-term, capital-intensive facility. They are usually built in locations that provide enough limestone for longterm operation. Cement is made from raw materials such as limestone, chalk, shale, clay and sand. These raw materials are naturally present in the quarry, and are extracted by different mechanisms such as blasting, hammering, scraping or any other method, and they are crushed, finely ground and mixed to obtain the correct chemical composition. A small amount of iron ore, alumina and other minerals can be added to adjust the raw material composition. Typically, fine raw materials are sent to a 6 large rotary kiln (cylindrical kiln), where they are heated to about 1450 ° C (2640 ° F). The high temperature causes the raw materials to react and form a hard spherical material called "clinker". The clinker is cooled and ground with gypsum and other small amounts of additives to produce cement.. (Gadayev, A., and Boris K.,1999)

The core of the all clinker production plants is the rotary kiln. In the rotary kiln process, the raw material mixture is fed into the upper end of a large refractory lined steel cylindrical kiln 60 to 300 meters in length and 3.0 to 8.0 meters in diameter. The mixed mixture is fed into the incline furnace at a rate controlled by the slope and the rotational speed of the furnace. Coal, petroleum coke, natural gas, and / or other fuels are fed to the lower end of the kiln and burned to feed the flame. The temperature of the flame can reach 1800 to 2000 ° C.

When the kiln rotates 1 to 5 revolutions per minute, the raw material slides toward the flame at the lower end of the furnace through the gradually burning area. In the furnace combustion zone, the raw material reaches a temperature of 1430°C to 1650°C. A series of chemical reactions makes the material to decompose, partially melt, and fuse into gray-black particles called "clinker." The hot exhaust gas discharged through the kiln is used to preheat and calcine the raw materials before they enter the burning zone of the kiln. The clinker is discharged into the cooler in the form of red hot particle from the lower end of the kiln and it lowers it to ambient temperature. The cooled clinker is mixed with gypsum and other additives and ground into a fine gray powder called cement. (M. Schneider, M. Romer, M. Tschudin, and H. Bolio, 2011)

The kiln system of a cement plant runs continuously while the plant is running. Except for occasionally shutting down for inventory control during periods of low demand, it is only shut down once or twice a year for regular maintenance. The startup and shutdown process is a carefully controlled process to minimize damage to the refractory brick lining and steel furnace shell. Care should be taken to avoid anything that would interrupt the clinker production process, such as clogging of the preheater or build-up in the kiln. When in an active state, the kiln must be kept at an appropriate temperature to achieve optimal cement production. The over burned material in the kiln wastes fuel and reduces the porosity of the clinker, resulting in higher energy consumption of the cement mill during grinding phase. Insufficient burning leads to incomplete reaction of the raw materials and poor nodulation. Poor management of cement kilns will result in increased cement kiln dust, which is more difficult to grind and handle than proper clinker nodules. (Maki et al., 1994).

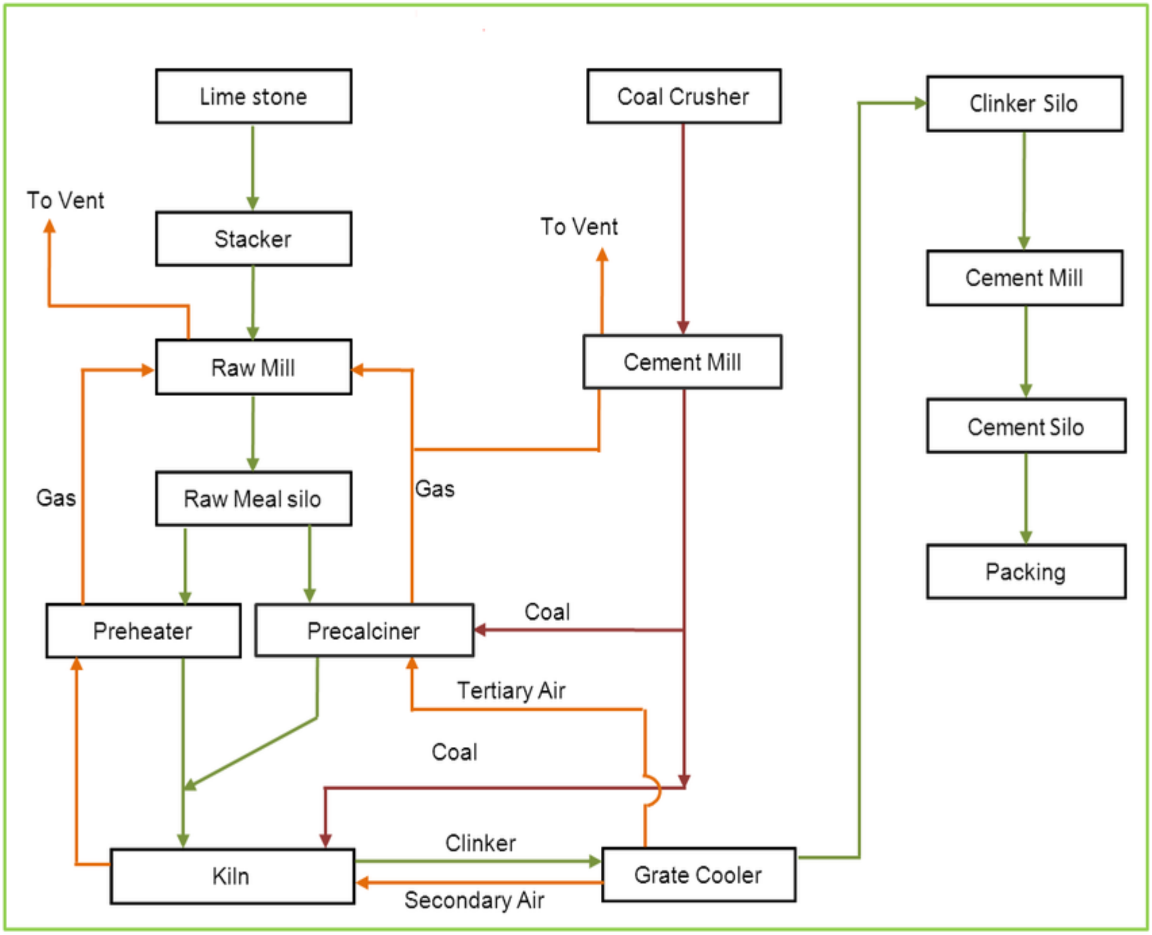


Fig 1-1 Cement manufacturing process
Source: Maki, I., T. Tanioka, Y. Ohno, and K. Fukuda, 1994

1.1.2 Section wise cement production process

a. Blasting and Crushing: The naturally found rawmaterial will be blasted by explosive to disintegrate and huge chunk of stones will be formded theses stones of large dimensions will be sent to the crushers to decrease their size to fed to the mills.
b. Transportation of lime-stone, clay and other additives from the quarries to the crusher: once the raw materials with a maximum size of 50mm are ready at quarry site they will be transported to the plat site. Most of cement plants situates their limestone crusher plant in the quarry to avoid huge boulders with dumb trucks as it is easy to transport the crushed limestone by conveyors to the plant site. Except

Habesha cement all the case companies transport the crushed limestone by belt conveyor whereas Habesha transports limestone by dump trucks cause the quarry is 70km away from the plant site. As consumption of Clay and other corrective materials comparatively very small dump trucks are used. Usually, these deposits are very near to the factory.

c. Grinding of the raw materials: grinding of the materials with the required proportion is carried out in different types of mills. Sometimes, hot air is used in mills to dry and grind the raw materials.
d. Transportation, storage and Homogenization: Bucket elevator, screw conveyor and air lift transportation is used to transport the ground raw mix to tall concrete silos where homogenization and storage is carried out. During and after the grinding operation the composition of the mix has to be corrected to the exact required content.
e. Burning (Pyroprocess): burning of the raw mix is the most important operation in the manufacturing of cement. The main equipment in this process is the kiln where morethan 40% of the production cost spent. In the burning processes the raw mix is measured and fed to in a counter current direction with hot gas (flue as) and in between the movements the material will be heated to a temperature where a liquid phase appears and reaction takes Clinker will be formed which is the main ingredient of cement.
f. Transport of clinker: the transport of clinker is carried out by drag chains or bucket conveyors to the respective silos or storage yards.
g. Grinding and storage of cement: of all the unit operations entailed in the manufacture of cement, grinding of clinker to cement is the most electrical power consuming. The most common equipment available is tube mills with two compartments. Usually storage of cement is made as bulk cement in concrete silos.
h. Packing of cement: Cement is ppacked and transported in two forms in bulk transport (mostly for large projects and batching plants or 50kg bag packaging means which is the most common one in Ethiopia. (M. Schneider, M. Romer, M. Tschudin, and H. Bolio, 2011)

1.1.3 Nature of cement plants

Cement factories by nature are

- Highly capital consuming

- Highly energy intensive (50 to 60% of the total production cost of cement in Ethiopian the cement plants is for energy while it is 30 to 40 % globally (Aklilu, 2016).
- Has to be operated as continuous as possible
- Highly labor intensive.
- Plants has to be located as near as raw material source (Away from cities)

During periods where it is financially or socially advantageous (In Ethiopia companies has to reduce the load during holidays and whenever there is a shortage of power supply to give the general public. To reduce electrical usage in cement plants has to shut down some numerous processes without interrupting proper kiln operation to reduce the load. The raw mill and cement mill are the highly loaded sections that can be interrupted. If the raw mill is stopped, crushers and conveyors from the quarry and raw material homogenization can also be shut down and the kiln can consume the raw mix from storage silos. The cement mill also can be shut down and the clinker can be stored in the storage silos. Most of the equipments run efficiently during steady operation, so for load shedding/power rationing to be feasible and acceptable the financial benefits from the utility must outweigh the cost of stopping and starting the equipments, both in wasted electricity and operator time.

1.1.4 Overview of Cement sector in Ethiopia

Cement is the most consumed product globally and very and a very important, un replaceable and essential input for infrastructure development specially for construction industry, particularly in Ethiopia the government is undertaking huge construction projects, infrastructure like dams, railways, roads and housing programs, which are the pillars of social and economic growth and development. For this reason the Government of Ethiopia categorized cement as one of the strategic commodities that need to be efficiently managed in order to sustain the growth of construction sector and infrastructure development in the country.

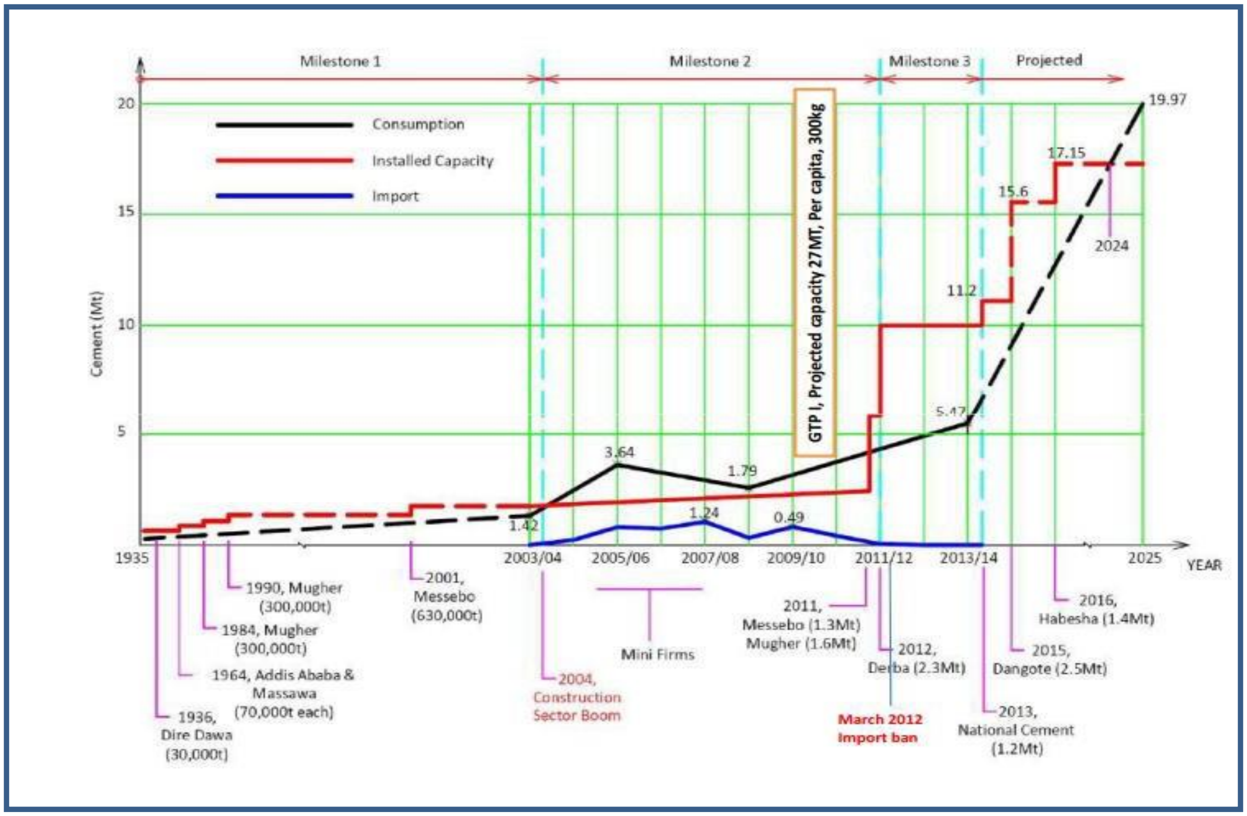


Fig 1-2 Projected production and consumption of cement in Ethiopia

Source: 7th African cement trade summit (Adama science and Technology)

As can be seen from the above figure the demand and consumption of cement is supposd to be balanced on 2024 with a little bit of higher production but in Ethiopia there is a shortage of cement supply. The shortage might be due to high consumption or less production but a survey done in March 2020 by FDRE Ministry of Industry the latter is true the plants are working too much below their capacity due to different reason and one of the findings in that survey for underutilization of the factories is frequent power interruption. The following table shows the installed capacity of the cement plants in Ethiopia and from this list our impact assessment will cover five of the biggest cement plants which are Dangote cement, Derba Midroc cement, Habesha cement, National cement and Mugher cement.

Table 1.1: Cement plants in Ethiopia and their respective capacities.

S. No	Plant	Installed capacity (tpd)
1	Mugher Cement	5000
2	National Cement	3400
3	Messebo Cement	5000
4	Derba Cement	5000
5	Dangote Cement	5000
6	East cement	1800
7	Ethio Cement	1800
8	Habesha cement	3000
9	Pioneer cement	1800
10	Mojo cement	900
11	Enchini bed rock cement	900
12	Holeta cement	300
13	Abysinia cement	200
14	Kuyu cement	1400
15	Dejen cement	300
	Total	

Source: East Africa Cement, Concrete and Energy summit

1.1.5 Energy requirement in cement production

The source of energy in cement manufacturing is mainly two which are Fuel oil and electricity. Electric power is used in crushing, grinding and conveying of raw materials finish products and to operate other auxiliary equipments like fans, blowers, coolers and other. Electricity is used in the main process of the cement manufacturing which is the kiln to produce clinker by burning the raw materials crushed and grinded. And it is a process which is fuel intensive.

There are two broad categories of clinker production process which are dry and wet kilns which have different heating and cooling processes and having different electric and fuel consumption. Wet kilns consumes less electricity and require significantly more fuel to burn where as dry kilns consumes less fuel and high electricity. In theory 430Kcal/ Kg clinker of heat is required to produce 1 Kg of clinker, but in practice two times is being consumed. The energy use in cement production is categorized in to three:

a. Electric energy for raw material preparation,
b. Fuel energy for clinker production, and
c. Electric energy for cement grinding and packaging.

With regard to electric energy consumption studies found out that the energy performance of cement manufacturing plants in East Africa is low with 105-140kwh per tonne of cement compared with the world average 85-95kwh/tonne of cement. This gap in specific electric energy consumption is believed to be from different technological difference and other factors like frequent power outages and other issues.

Cement manufacturing process is an integrated continuous process and it involves a multiple mechanical and chemical unit operations which are working sequentially. If once stopped for whatever reason it will cause a lot of damage and loss to restart it and put it back to a stable operation.

1.1.6 Overview of Ethiopian Power sector

Electrical and Thermal energy is the main source of energy for most industries to run their equipments like motors, pumps, boilers, compressors, furnaces, diesel generating engines, refrigerators and in the conversion of inputs to outputs like drying burning and other processes. But there quite lot of challenges in the manufacturing sector to efficiently use their energy. Due to this they incur lots of money on energy bills and this affects the industries competitiveness. (Phil Kaufman and Marcia Walker, 2009.)

Ethiopia‘s government is giving a lot of attention to generate adequate electricity by to its consumer but not much is being done to check that the amount of energy presently being generated is efficiently used and weather the customer is satisfied or not. Industries have their efficiency in their usage of electricity and the service provider has to establish a better monitoring mechanism to improve their efficiency at the time there should be a check and balance mechanism for the customer also to question the quality of service being given by the service provider.

Ethiopia is one of the fastest-growing developing nations in Africa with huge potential in energy resources. According to the USAID country fact sheet published in 2016 Ethiopia has the potential to generate 60,000MW of electricity from different sources like hydropower, wind, and geothermal. The following two tables which is available on the website of Ethiopian Electric power (EEP) shows the potential of electric generation capacity and installed capacity.

Table 1.2: Electric generation potential in Ethiopia

Resource	Unit	Exploitable Reserve
Hydropower	MW	45,000
Solar/day	kWh/m2	Avg. 5.5
Wind: Power	GW	1350
Geothermal	MW	7000
Wood	Million tons	1120
Agricultural waste	Million tons	15-20
Natural gas	Billion m3	113
Coal	Million tons	300
Oil shale	Million tons	253

Source: Power Sector Development POWERING AFRICA 2014

Table 1.3: Ethiopias Electric power sources

Resource	Unit	Contribution	%age
Hydroelectric	MW	3781	89
Wind	MW	337	8
Thermal	MW	126	3

Source: Ethiopian Electric power

This installed capacity is equivalent to 7%of the potential. Because Ethiopia is rich in water resources and hydropower is relatively cheap Ethiopia is considered as a country that can produce enough power for domestic use and even to sell to neighboring countries. However the rainfall in Ethiopia varies considerably from year to year and therefore, over-dependence on hydropower makes the energy supply very unstable and unreliable. The instability of the energy supply brings about negative impacts on the industry and the economy.

The Government of Ethiopia, under its latest Growth and Transformation Plan (GTP), plans to transition from a developing country to a middle-income country by 2025. Ethiopia‘s ability to achieve this goal in the sectors such as agriculture and industry is significantly constrained by challenges in the power sector. The challenges in the power sector is not only coming from unreliable and less generation but also power loss due to old and poor power grid distribution and interruption due to overloaded power lines and substations.

According to data from EEP website, Electric power consumption has been increasing for all types of users in the table below (Industrial, commercial…). For the period 2008/09–2014/15 in Ethiopia industries has been the number one users of electricity followed by households. Increased power consumption by households is mainly due to the increasing use of electronic household.

1.1.7 Customer Type and Structure of Electricity Tariff In Ethiopia

Electricity Tariff- is the amount electrical energy is being sold to a consumer. Electricity tariff (sometimes referred to as electricity pricing or the price of electricity) varies from country to country, and may vary widely from area to area within a particular country. There are many reasons that account for these differences in price. The Ethiopian Electric Utility made an adjustment to the Electricity/energy tariff applicable since the beginning of December 2018.

Table 1.4: Ethiopia electric energy Tariff

Customer Category	Tariff structure	Tariff
Domestic (Single or three phase)	Up to 50 KWh;	0.2730
	Up to 100 KWh;	0.5617
	Up to 200 KWh;	1.0622
	Up to 300 KWh;	1.2750
	Up to 400 KWh;	1.3833
	Up to 500 KWh;	1.4965
	Above 500 KWh;	1.5870
General and Commercial (Single or three phase)	Flat rate	2.1240
Industrial Low Voltage	Flat rate	1.0544
Industrial Medium Voltage	Flat rate	0.8008
Industrial high Voltage	Flat rate	0.6540

Source: Ethiopian Energy Authority Tariff Guideline and Methodology

Sustainable electric power supply is a decisive factor in any economy, developing countries faces 250 outages (close to 1,000 hours) a year, while developed countries experiences only 1.5 outages (approximately 3 hours) a year. The frequency and duration of outages also vary significantly among regions. Sub-Saharan African economies have the longest outages, averaging almost 700 hours a year, While OPEC high-income economies have the shortest, averaging only about 1 hour (Doing business database, 2016).

As there is still an issue of supply of reliability access is still a problem. The information on the website of Ethiopian Electric power website states that a total of 2100MW power is waiting to be supplied to the sectors within two years‘ time

Table 1.5: Requested power for different sector

S.no	Sector	Rquired Power
	Cement Factories	700 MW
	Steel & Metals	800 MW
	General industry	600 MW
	Mining	100MW
	Total	2100MW

Source Applications for new industrial developments received- EEP (EEP website):

1.1.8 Ethiopia’s electricity tariff Comparison:

Compared to different countries in the world Ethiopia‘s Tarif is one of the lowest.

Table 1.6: Electricity Tariff for different countries

S. No	Country	Tariff (USD cents)
1	China	7.5
2	Brazil	10.7
3	Egypt	16.20
4	France	9.6
5	Germany	19.39
6	India	35.25
7	South Africa	8-12
8	Turkey	8-16
9	UK	12.57
10	US	20
11	Ethiopia	5.6
10		

Source: energy4sustainablefuture

When compared with other African countries Ethiopia has lowest rate for electricity, let alone the international standard.

This is the biggest privilege and incentive for investors mainly for those who wants to join the manufacturing industry which are power intensive like steel and cement, but at the same time the quality of the sustainability of the supply is disappointing the firms which are already in operation.

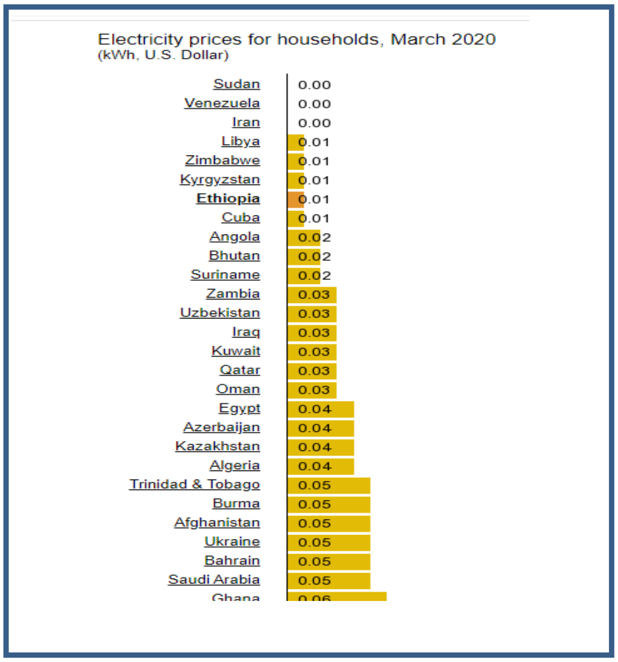


Fig 1-3 Electricity price for house holds for 28 countries with the lowest tariff

Source: (Doing business database, 2016).

1.1.9 Power supply reliability Index

The reliability of the power supply is assessed using the reliability indices. The indices for distribution system analysis include customer-oriented indices and load or energy-oriented. (Richard E. Brown, 2007, Valerie E. Zelenty, 1999, C. R. Bayliss and B. J. Hardy 2002).

A. Customer-Oriented Indices

i. System Average Interruption Frequency Index (SAIFI): is the average frequency of long interruptions per customer over a specific area. Total number of interruptions per year divided by the total number of customers served.
ii. Customer Average Interruption Frequency Index (CAIFI): This index shows the average frequency of interruptions for those customers experiencing interruptions. Total number of customer interruptions divided by total number of customers affected.
iii. System Average Interruption Duration Index (SAIDI): It is commonly referred to as customer minutes of interruption or customer hours and provides information as to the average time the customers are interrupted.
iv. Customer Average Interruption Duration Index (CAIDI): It is the average time needed to restore service to the average customer per sustained interruption.
v. Average Service Availability Index (ASAI): This index represents the fraction of time (often in percentage) that a customer has power provided during one year or the defined reporting period.
vi. Average Service Unavailability Index (ASUI): This index is the complementary value to the average service availability index (ASAI).

B. Load or Energy-Oriented Indices

i. Energy Not Supplied Index (ENS): This index represents the total energy not supplied by the system.
ii. Average Energy Not Supplied Index (AENS): This index represents the average energy not supplied by the system.
iii. Average Customer Curtailment Index (ACCI): This index represents the total energy not supplied per affected customer by the system.
iv. Average Load Interruption Frequency Index (ALIFI): This factor is analogous to the System Average Interruption Frequency Index (SAIFI) and describes the interruptions on the basis of connected load (kVA) served during the year by the distribution system.

Average Load Interruption Duration Index (ALIDI): This factor is analogous to the System Average Interruption Duration Index (SAIDI) and describes the number of hours on average that each kVA of connected load was without service. (Richard E. Brown, 2007, Valerie E. Zelenty, 1999, C. R. Bayliss and B. J. Hardy 2002).

The above are service reliability measurement indexes that are usually used in developed world in this thesis we will use the indirect measurement of the impact by using a choice experiment which will be discussed in the later section.

1.1.10 Background of Case companies

Ethiopia's cement consumption is growing at very high rate annually for the past decade but the supply of cement is stagnant if not decreasing due to different reason due to the scattered nature of the companies geographically it was not possible to cover all the companies but it is believed the results from this research can be extrapolated to the others.

The case companies selected for this thesis are located in different region of the country; National cement is in eastern Ethiopia at 500 km from the capital, Derba cement, Mugher cement, Dangote cement and Habesha cement are found in found at almost center of the country close to the capital Addis Ababa. The companies owner ship is a mix of Private, Government and Foreign investors. The companies started operation at different times and did also up gradation work in Different times. These companies use power lines from the interconnected system which means they use power line from the national grid and the problem faced by one company will most likely be faced by the other also. The distribution of the companies at different region of the country will help in giving a representative result to conclude the problem and solution at national level by using these results. In the following section we will give a short background of the case companies.

1.1.10.1 Mugher cement Factory

Mugher cement factory lies 105km west of the capital, Addis Ababa, Located in Oromia regional state West Shoa zone Berga Woreda. The mugher cement factory: the mother plant of the enterprise is a factory with two production lines. The first line started operation in 1984 G.C and the second one commenced production in 1990. Each line has a production capacity of 1000 tons of clinker per day. The type of cement technology used by Mugher cement factory is a dry process five stage preheater kiln with rotary cooler. The cement production is continuously monitored. This activity is mainly carried out at the central control room. On line monitoring is conducted at each step so as to ensure smooth flow of production.

There was Addis Ababa cement plant formerly known as Addis Ababa cement factory was built in 1964.e.c. Initially it had a production capacity of 70,000 tons of cement per annum. However, following the obsolescence of the machineries and increase in the emission level, which brought about pollution in the surroundings, the plant has been forced to stop production of clinker in 1996. It, however, is reconditioned into a grinding plant and starts grinding and packing clinker about 100,000 tons of clinker per year from MCF and produces ordinary Portland cement and Portland pozzolana cement as a major product. Portland pozzolana cement is also produced by the plant when the need arises but now the plant is completely dismantled and the land is taken for other purpose. The newly built Mugher cement Tatek cement grinding unit is the latest project under Mugher cement Enterprise and comparatively operating with a better efficiency that other lines. Mugher cement plant is the oldest and the only government owned cement Factory in the country

In addition to the cement plants Mugher is operating a plant that produces paper bag for cement packaging. This plant was established in year 2000 with the objective of producing and supplying paper sacks which are to be used for packing cement, lime, fillers and other products. The plant also has a production line for producing paper made bags for the market. The production capacity of the plant is 60 million pieces of shopping bags per annum.

Products of the factory include:

a. Ordinary Portland Cement(OPC)
b. Portland Pozzolana Cement(PPC)
c. Quick and hydrated lime
d. Paper sacks and shopping bags. (Company website)

1.1.10.2 National cement Share Company

National Cement Share Company is located in the Eastern part of Ethiopia, in the city of Dire dawa at 515 km away from the capital city of Addis Ababa. The establishment of the current National Cement Share Company (NCSC), the former Diredawa Cement & Limestone Factory, dates back to 1936 G.C. Established by Italians, during occupation in 1936, and being the pioneering cement producing and selling factory in the country, The company has added a clinker grinding and packaging unit in koka town near the city of Adama with a capacity of 800 tpd. In total the factory has the capacity of 4500tpd ordinary Portland cement and Portland pozolana cement.

At the moment, the company creates job opportunity for a total of 1450 employees, both at managerial and operational occupations.

1.1.10.3 Dangote cement Factory

Dangote cement is a The 2.5Mta plant located 90km far from Addis Ababa on the way to mugher cement factoy, was commissioned and started operation in May 2015, it is the largest cement plant in Ethiopia capable of producing high-quality 32.5 and 42.5-grade cements to meet market needs. (Company website)

1.1.10.4 Derba Midroc Cement Share

The Derba Midroc Cement plant project, located 70 km north of Addis Ababa, was approved in November 2015. It involves mining the Derba-Mugher limestone deposit of 165 million tons of limestone and treating it in a cement plant. The plant has a capacity to recover 5,600 tons per day of clinker and 7,000 tons per day of cement as a finished product. The factory is established with a total investment of 351 million USD and it is one of state of the art cement factory with abundant auxiliary facilities. (Company Website)

1.1.10.5 Habesha Cement Share company

Habesha cement is a cement producer operating in Ethiopia engaged in the production of two types of cements such as Portland Pozzolana Cement (PPC) and Ordinary Portland Cement (OPC).

The company is located in Oromiya regional state in Welmera Woreda, Holeta town, 35 km from Addis Ababa. The plant is located at proximate distance from the raw materials deposits and the main cement market, Addis Ababa, and its surroundings.

Currently, the plant has a capacity of producing 3,000 tons of clinker and 4,500 tons of Portland Pozzolana Cement per day, which is 1.4 million tons per year at full operation.

The Plant is operational since its inauguration in mid-January 2017 with a production of Ordinary Portland Cement Class 42.5 and Portland Pozzolana Cement Class 32.5. Besides its cement products, the company is planning to produce and market Aggregate Ready Mix Concrete and Gypsum Boards. (Company Website)

1.2 Statement of the Problem

Ethiopia has failed to meet the increasing demand for energy for various reasons, including an over-reliance on hydropower generation which is being hampered by climate variation. Inadequate alternative energy sources and insufficient technological advancement. In addition to the above capacity problems the electricity supply sector is tied with a complex bureaucracy in the state-owned and monopoly energy sector. In Ethiopia, poor electricity supply is the greatest problem confronting the manufacturing sector. World Bank's Enterprise Surveys, published to the years 2006–2010, 2015 stated that a typical Ethiopian firm experiences power outages during a typical month 10.5 times while the average length of an outage is 6.6 h. Voltage fluctuations without a prior warning which result in machine failure is the other challenge. This imposes a huge cost on the firm arising from idle workers, spoiled materials, lost output, damaged equipment, and restart costs. The overall impact increases business uncertainty and lower returns on investment. Ethiopian Electric Power (EEP) and Ethiopian Electric Utility (EEU) are the public enterprises responsible for generating the power and distributing the power respectively. The earlier one has the authority of constructing and administration of the power generation plants, high voltage transmission lines, substations, and wholesale of electricity for heavy industries consuming 10MW and more.

In the year 2019, the country faced a huge power shortage due to drop in water level in the hydropower dams and the government adopts rationing for homes and industries as an immediate attempt to remedy the national power crisis this rationing has forced steel and cement industries to operate fewer shifts and less capacity. Many small and medium-scale enterprises invest by their own stand-by backup generators to ensure an electricity supply, but these are often expensive compared to electricity from the grid. Even this option is not on the table for heavy industries as the investment cost and operating cost for huge diesel generators that can run fully or partially a cement plant is too high to even consider it. The study will enable us to measure the impact of power outage characteristics like pre-informed outages, sudden outages, and others on outage costs, productivity, and performance of the firm in the long term. In terms of scope of coverage the study will focus on and analyze the manufacturing sector especially the cement manufacturing industries. The study will analyze and provide useful data for measuring the willingness of consumers to pay for reliable electricity supply measure the inefficiency and will be a basis for reform of the Electric Authorities.

1.3 Objective of the study and Research questions

1.3.1 General Objective

The general objective of this study is to assess the overall impact of power outages and to evaluate the cost of the power outages on the performance, productivity, profitability and overall impact on the cement plants and also to determine the extent of the demand for improved electricity services.

1.3.2 Specific Objective

- To evaluate the current state of power outages to the cement manufacturing sector in Ethiopia.
- To assess the impact of power outages on plant capacity utilization, productivity, turnover, performance, product quality, maintenance, etc., and cost of doing business in general.
- To estimate the companies willingness to pay (WTP) for power supply with lesser interruption.
- To outline recommendations for the industries to cope with the problem.
- To recommend solutions for policies which are aimed at improving sustainable and reliable electricity supplies for cement industries.

1.3.3 Research Questions

In order to achieve the above objectives of the study this thesis work has to answer the following research questions.

- What are the impacts on cement plants due to power interruptions?
- What is the extent of the current power outage in Ethiopia?
- Are the companies willing to pay extra for an improved electric power supply? If so how much they are willing to pay?
- What are the implications of the policies regarding sustainable electric supply?
- Are there any measures that the companies can take to cope with the problems?

1.4 Scope of the study

The scope of this study will be assessing the impact of power outages in Ethiopian cement industries in the case of cement industries in Ethiopia. The five biggest cement factories; Dangote cement plc., National cement plc., Habesha cement Plc., Derba cement Plc and Mugher cement (supplying 60% cement to Ethiopia‘s market) will be considered as case companies that are.

1.5 Significance of the study

mostly, figuring out to what amount the power outages is affecting the companies performance and productivity and estimating the firms WTP for dependable power supply may additionally help the authorities to work on the essential policies in the direction of the critical sectors primarily based on their economic contribution and WTP values. besides, the paper may be used as supplementary refference for the concerned governmental policymakers as well as for the researchers' who are interested to make a complete assessment of the effect of power outages on national economies and impact of it in different manufacturing sectors like steel and others heavy and medium scale industries.

This paper contributes to the few or nearly none literature into the research of effect of electric power outages on productivity and performance and additionally emphasizes the significance of sustainable electricity to the performance of the manufacturing sector in Ethiopia. In this paper we ask by how much electricity power outages have affected the heavy manufacturing industries how much they're willing to pay additionally for sustainable supply. It will also contribute to the body of knowledge by showing an indirect method (The direct accounting method is by using the accounting data to calculate the impact) of impact assessment in researches by using willingness to pay method and comparing the two results.

So far, no much has been performed concerning effect of frequent power outages in Ethiopia‘s manufacturing sector as a whole and particularly within the heavy enterprise sector. For this reason this work will contribute to the existing few literatures for Ethiopia in this area. Moreover, the end result of this paper will be very usefull and interesting to the federal and regional authorities‘ and other involved bodies in supplying statistics for designing improved power provider. In addition to policy makers the paper contributes to the body of knowledge by giving a WTP index in Ethiopia ehich is an index useful to develop other indexes related to investment attractiveness and others.

CHAPTER TWO

2 LITRATURE REVIEW

Numerous numbers of literatures has documented the indispensable importance of access to a reliable supply of electricity for sustainable economic growth. According to (Andersen and Dalgaard, 2013; Dinkelman, 2011; Lipscomb et al., 2013) frequent power interruptions on households damages electronics items and inventory foods stored in fridges and in addition to this when there is an extended outages and frequent power interruption, Customers starts to begin to look for different items and utilities to fulfill their daily demand for cooking as well as for lightening purposes, which will increase the demand for alternative power sources like buttane gas and firewood based on their living standard and availability. As a result, the scarcity of firewood has come to be acute which results in a non-stop upward push in prices, and consequently growing the monetary burden on the family budget.

On the other hand (Arnold, Mattoo, & Narciso, 2008; Escribano, Guasch, & Pena, 2009) described the power interruption impact on businesses as Poor electricity supply has proved to be the major constraint to the business sector in Africa and has contributed to the low productivity and poor competitiveness of the manufacturing sector within the continent. This is evidenced in some studies examining the impacts of power interuptions on the performance of business enterprises in Africa. Unreliable electricity supply has a significantly terrible impact on a firm's total factor productivity.

As per Nakajimas (1988) research finding as Availability measures the overall time that the machine is not operating due to the fact that of breakdown, maintenance, and other stoppage reasons. It indicates the ratio of actual running time to the scheduled operating time available and any unplanned stoppage like power outages immediately influences the availability by decreasing the machine availability. And as performance measures the ratio of actual working rate/ capacity of the equipments and the actual capacity (based on the equipment capability as at the start designed) performance will also be impacted due to unplanned power outages.

World Bank Survey, 2010 mentioned that the quality of electrical energy supply, measured in terms of outages and voltage fluctuation, varies significantly between countries however is not often measured or described. As per this survey Between 2006 and 2010, more than 50% of the Sub-Sahara African firms identified electricity as a major constraint to their businesses compared to just 27.8% that named transportation as the most critical problem.

However, Escribano et al. (2009) concluded that bad infrastructure quality has a vast negative influence on firms productivity, and that poor quality electrical energy supply is the infrastructure aspect that has the strongest negative impact on company productivity, mainly in poor African counties. In a study of the influence of rural electrification on household income in India by Chakravorty et al. (2012)5e concluded that the reliability of electricity supply is more essential than being linked to the grid.

The same world Bank survey assess the impact of electricity insecurity on productivity at the level of a firm looked at the cost of interruption, cost of back-up generators and effect on productivity (using a production function). By Surveying data for over 1,000 firms in 10 Sub-Saharan African countries has showed that an unreliable electricity supply has a significant negative impact on a firm's total factor productivity. Another study by (Moyo, 2012) examining the impact of power disruptions on firm productivity in the manufacturing sector in Nigeria shows that power outage (measured using hours per day without power and percentage of output lost due to power disruptions) have a negative and significant effect on productivity. The analysis of this study found that power outages have a negative and significant impact on productivity in small firms, but an insignificant effect in large firms, probably due to generator ownership patterns.

Ethiopia long-term goal of the five year development strategy to become a middle income country in 20-30 years is highly challenged by poor electric power supply. Since Ethiopia is not an oil producing country, it should achieve this target by strong industrial development and this can be achieved only by supplying a sustainable electric energy.

Cissokho and Seck (2013) to the contrary finds out that outages were found to have a positive and significant effect on the productivity of small firms, and SMEs performed better than large-scale firms. The suggested explanation for this contradictory finding is that outages stimulated better management practices, which mitigated the negative effects of power supply interruptions, and that the more inefficient, lower productivity firms had gone out of business in the face of electricity insecurity. Carlsson F., Demeke E., Martinsson, P and Tesemma T. (2018) &. Fisher-Vanden et al. ,(2015) supports the argument that some firms might go out of business due to the fact that an increase in electricity shortages increases the unit cost of production of Chinese firms by about 8 percent they also concluded that frequent and prolonged outages are causing substantial economic damages to small manufacturing firms in Ethiopia. They find out also the total cost of outages for a firm is about three times their monthly electricity tariff.

Other studies recommends to use a top down based on lost added value for example a study by De Nooij et al (2007) that technique. This approach requires that all activities within a firm are checked based on their dependence on electricity and the impact of possible restrictions on the process of adding value due to interruptions. That way an impact of interruptions on activities relevant to adding value and activities dependence on electricity unsupplied from the grid is summarized. Thus the overall dependence of the entity in question can be inferred from the aggregated monetary losses due to certain activities being impossible.

Kariuki KK, Allan RN (1989), and Wacker G, Billinton R (1996) concluded that Several indicators can be employed to evaluate power cuts. Observations of the after-effects of a power cut such as the sum of losses to all market participants are the most important parameters for judging the macroeconomic significance of a power failure incident. To counter this effect of a power cut the government should intervene and should have a short and long term plan to solve the problem in priority basis based on the impact sector by sector and should design appropriate policies to support the firms for backup systems.

To cope with the problem of power outages, firms have to employ different strategies in developing countries, such as more flexible production and improved storage capacity. One obvious strategy is to invest in backup generators, such as diesel generators. (Eifert et al., 2008) Backup diesel generators are costly, and it is estimated that in Sub-Saharan Africa self-generated electricity costs three to ten times as much as the electricity purchased from the grid. (Foster and Steinbuks, 2009). Even if a firm uses a generator, it would still face output loss, since substantial time and cost are associated with restarting machines after an outage, and the self-generated power might not be sufficient to run production at full capacity (Beenstock, 1991).

A study by Eifert et al (2008) concluded that firm competitiveness is also dependent on product quality and the ability to meet orders on time, as well as unit costs. Electricity insecurity may impact both of these factors, e.g. by causing firms to resort to manual methods that reduce product quality, or to halt production and delay order delivery.

In countries with low electricity reliability, generators are the preferred mitigation option for many electricity dependent businesses to sustain regular business operations but in case of heavy industries, the amount of power they need cannot be easily covered by a stand by generators (Attigah and Mayer-Tasch, 2013), although often generators are not used to provide much if any motive of power during outages and the upfront purchasing costs and subsequent running costs make them prohibitively expensive, to smaller firms in particular.

(Braimah, I., & Amponsah, O. 2012) argue that fewer interruptions in the power supply could be a means of charging realistic tariffs as consumers may have value for the tariffs they pay. As per the US Department of energy to fully understand the consequences of the power outages, the impacts caused by these events must be analyzed and classified carefully. In the impact assessment report prepared by the US Department of Energy after the 1977 New York City blackout the impacts of power disruptions were grouped into two main categories: direct and indirect impacts. The direct impacts cover loss of manufacturing and production, interruption of services such as transportation, telecommunication, and so on, loss of sales, damages on the equipment, spoiled goods, damages on the electronic data, accidents, and injuries. To measure the monetary worth of these events is a relatively easy task when they are compared to the indirect impacts of the power disruptions. The nature of the indirect consequences of the outages is quite complicated. Some of them reveal the true costs in a longer period.

Like other commodities, electrical energy is also sold at such a rate so that it not only returns the cost but also earns reasonable profit. Therefore, a tariff should include the following items.

- Recovery of cost of producing electrical energy at the power station.

- Recovery of cost on the capital investment in transmission and distribution systems.
- Recovery of cost of operation and maintenance of supply of electrical energy e.g., metering equipment, billing etc.
- A suitable profit on the capital investment.

The tariff should be such that it ensures the proper return from each consumer. In other words, the total receipts from the consumers must be equal to the cost of producing and supplying electrical energy plus reasonable profit. This will enable the electric supply company to ensure continuous and reliable service to the consumers. In the case of Ethiopia Ethiopian Electric Power (EEP) is a monopoly supplier of Electric power due to the reason that there is no competition the utility company is not striving to give a satisfactory service to its customers. According to EEP website till date the electric supply is subsidized by the government but the government of Ethiopia has decided to increase the tariff at least to cover the generation and distribution cost.

The tariff rate of charge of electrical energy is set to make big consumer to be charged at a lower rate than a small consumer. It is because increased energy consumption spreads the fixed charges over a greater number of units, thus reducing the overall cost of producing electrical energy.

World Bank's Enterprise Surveys, published to the years 2006–2010 stated that the average number of power outages during a typical month is 10.5, while the average length of an outage is 6.6 h. unsurprisingly; more than 50% of African businesses surveyed cite inadequate power supply as a major business constraint. Overall, there is no doubt that a deficient power infrastructure retards economic growth (Eberhard et al., 2008). The same survey also found that the average firm in Sub-Saharan Africa lost about 49 hours of economic activity in a typical month as a result of outages in 2015. Among Ethiopian firms, on average a firm lost about 47 hours of economic activity per month as a result of outages for the same period. The firm‘s willingness to pay, and thus the cost of power outages, is substantial.

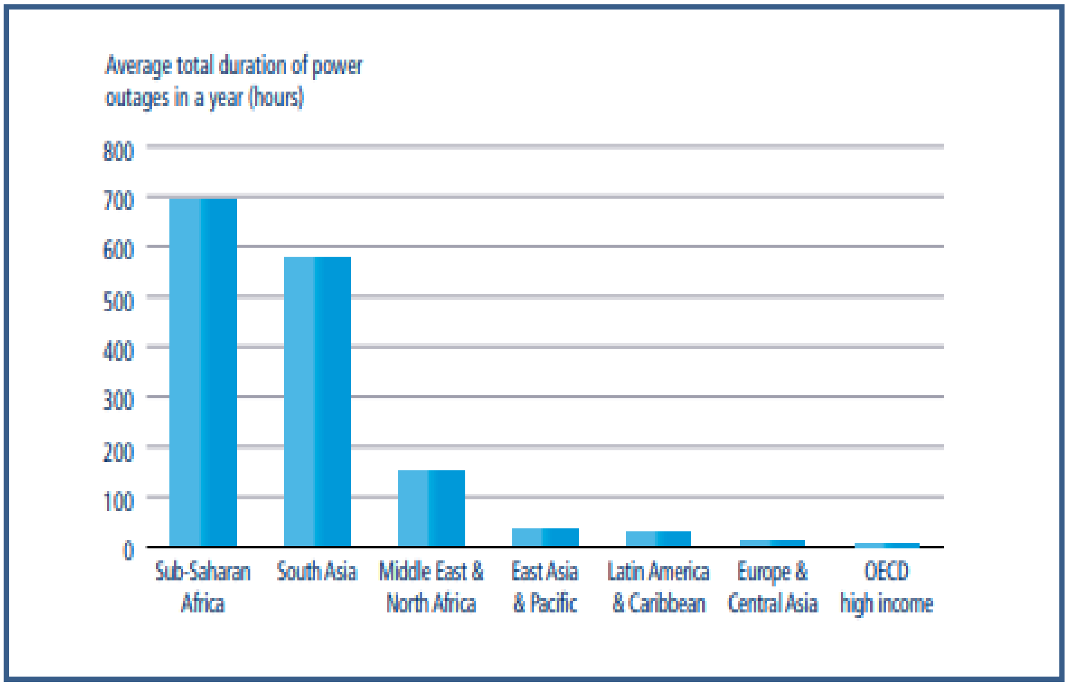


Fig 2-1 Average total duration of power outages in a year for different regions

Source: Doing business database

R. Herman and C.T. Gaunt, (2008) divide the type of electricity interruption into three: momentary interruptions, sporadic interruptions, and chronic interruptions. Momentary interruptions last for a very short time typically some seconds, or even less than one second. Sporadic interruptions have resulted from harsh weather conditions such as storms, floods, or thunderstorms. This type of interruptions poses a great threat to the power system since they cause long-lasting blackouts which mean significantly high economic losses for the members of the electric power system. Chronic interruptions, on the other hand, might be triggered by many factors. Poor power system planning and operation, insufficient power generation, the faults caused by the power system operation or overloading of the system, and faults in the power system due to aging or lack of maintenance are some of the main sources of the chronic interruptions. To fully understand the consequences of the power outages, the impacts caused by these events must be analyzed and classified carefully.

A lot of studies by different scholars in the past supported the conclusion that electricity enhances productivity at the economy-wide and the firm level (Fedderke J. and Bogetic, Z. 2006; Kirubi et al., 2009; Grimm et al., 2011). Unreliable electricity supply seems to be the infrastructure element with the strongest negative effect on enterprise productivity, especially in Africa (Escribano et al., 2009). The duration of outages (typically measured by hours in a day) has a far greater negative impact on firm productivity than the frequency of outages (days per month that outages occur) (Moyo, 2012).

Table 2.1: Summary of Surveyed researches and Studies

No of Study surveyed	Focus	Focus Region	Findings
6	Outage Cost	Sub Sahran African	Outages are highly impacting firms (decreasing their productivity and efficiency)
9	Back up means cost	Sub Sahran African	3 to ten times of the cost from the Grid
6	Power interruption impact	North African and Middle East	Outages are highly impacting firms (decreasing their productivity and efficiency)
5	Willingness to pay for improved service	Europe	Firms are willing to pay from 1% up to 10% more for uninterrupted supply
5	Outage cost	Central and East Asia (India and China)	Costs the company up to a decrease of 5 % in productivity.
11	Outage Impact and Willingness to pay	Global	Willing to pay up to 5% more for uninterrupted supply

As can be seen from the above surveyed literatures and summarized table most of them strongly agree the impact of power outage is significant however there is no study conducted in Ethiopia as a whole except one study which has focused on outage cost on household level and also no specific study which has focused on Ethiopia‘s cement industries and also and which has employed two methods which are direct financial loss and Willingness to pay of the customer for reliable power supply and also there are no studies that shows an Ethiopian firm Willingness to pay for reliable power supply as other countries. So this study will fill these gap and conduct the study by employing two methods direct financial loss using a secondary data from case companies and also estimating the willingness to pay by collecting data using questionnaires.

CHAPTER THREE

3. METHODOLOGY

The preferred methodology for estimating the power outage cost is surveying the customer using different means like interview and questionnaire. In the survey, questions asking the customer the cost of interuptions at several time durations at different times of the day (during working hours and outside working hours) and different times of the year. This method is preferred from the others due to the fact that it gives more reliable and enough outage cost data for conclusion and decision.

3.1 Data collection

The necessary data for the thesis are collected from primary and secondary sources

- The Power interruption and frequency of interruptions of the case cement factories factory for the last five years were collected from the companies‘ record.
- Production loss of the companies due to power interruptions were collected from the companies‘ record (Production report).
- Questionnaires were used to collect primary data about the workers perception on power interruption and companies‘ willingness to pay for improved power supply service.

Then the data are analyzed quantitatively and qualitatively. From the analyzed data, conclusion and recommendation are forwarded.

Five cement plants in Ethiopia are chosen to study the power interruption impact and as they are the mostly affected sector in many aspects. Large industry customers like cement plants employ professionals who know about the costs of the power interruptions. Even though predicting the exact costs of power outage events is not possible, these personnel are expected to give information and responses as credible as possible answers to the questions of the surveys.

The questionnaires were distributed and collected via electronic communication and in person method. While using this method the questionnaire is distributed to the selected respondents in the cement sector and received them when they have been duly completed. 180 questionnaires were distributed and out of which 168 were returned and all found to be adequately completed. Microsoft excel software was employed to code the data and to analyze some of the data. The questionnaire is designed to know the educated opinions of the respondents towards power interruption by using hypothetical questions and also by giving sets of choices between different attributes against extra charge (Willingness to pay) for the service and Stata 13.0 software was used for it. A detail explanation of the design of the questionnaire is discussed under the methodology section.

3.2 Methodology

There are two broad approaches (methods) used to measure the impact of power outage, the accounting approach, which makes use of direct financial loss incurred by the power cut referring to accounting records or production reports and econometric/statistical techniques which uses an indirect method by asking people to choose between different options to minimize the outage. This research will employ both techniques to some extent.

In the manufacturing sector, there are overhead costs that will be incurred whether the plant is operating or not. The opportunity cost of lost production during the outages will be measured by the lost contribution of the production towards overhead cost and profit. There will be other losses that will be considered in this study like material spoilage to measure the total value of the power outage cost.

The study employs a combination of quantitative and exploratory qualitative methods to assess the cost and the Impact of Power Outages on heavy Manufacturing Industries in Ethiopia specifically the cement industries. The research will employ an extensive review of relevant theories and literature related to power outages and the impacts of it on the firms' productivity and performance directly or indirectly. The study will use semi-structured interviews to gather primary data related to power outages.

Secondary data from the industries record on each of the power outages that affected the production are used. All of the records are based on the actual records of the firms. The impact of a power failure on production time lost is much longer than the duration of time of the power failure itself. So, to estimate the total production time lost, it is required to add the additional time needed to resume the production after a power failure to the duration of the power failure.

Loss due to unsupplied electricity is a measure of the opportunity cost of marginal power supply for an enterprise. In other words, this would be the willingness to pay value for the supply of power which would prevent an outage. We will take this value and compare it with the primary data which will be collected by direct interview and questionnaire which will be filled by the firms. A choice experiment is employed in the questionnaire, the customer is asked to choose from three options in addition to the current situation. The alternatives will be an additional payment for a reduction of no. of power outages and duration of each.

In Choice Experiment, the individuals are given a series of hypothetical situations and asked to choose their most preferred alternative among the given ones in a choice set. The CE is a multi-attribute stated preference fact finding thechnique because each alternative is described by some attributes or characteristics. A monetary value is included as one of the attributes, along with other attributes of significant importance. When individuals make their choice, they behind make trade-offs between the levels of the attributes in the different alternatives presented in a choice set (Alpizar et al., 2001).

3.2.1 Design of Choice Experiment

Choice experiment is made by preparing a questionnaire to be filled by respondents. In this study the respondents were given with 6 choice sets with two electricity service alternatives and the status quo (the current scenario). In each alternative Frequency of interruption, type of interruption and duration of interruption but in different levels. For each set, the respondents will state which alternative they think is best for their company. It is expected that their choice will not affect anything other than the attributes and the additional cost on monthly electricity bill, everything else remains as it‘s with the status quo.

In the questionnaire before starting the choice experiment the respondents are given a general introduction about power outages and how the power service providers can minimize them by investing on infrastructures like dams, upgrading the technology and the capacity of grids, transmission and distribution lines and also improving customer service in case of technical failures. Once the introduction is done it is followed by a description of each scenario (see Appendix A). The scenario focused on the respondents belief on willingness to pay to reduce the power outages by considering that the Ethiopian Electric Utility could improve reliability by making investments. The main effects of these investments would be a reduction in both the frequency and duration of power outages experienced by the firm. The trade-off for the respondents would be a reduction in the attributes and increased electricity prices. To help the respondents better understand the cost attribute, a percentage increment from the current service is used. Finally there are a follow up questions. These are questions comes immediately after the choice set questions to explore the motivations behind respondents‘ choices.

Electricity as a service consists of attributes and benefits that respondents identify and value in relation to their educated preferences. When it comes to house hold electric power users it is about comfort, entertainment and other activities when they think of the attributes but when it comes to manufacturing companies specially heavy manufacturing companies like cement power cut or interruption is about a short term impact like loss of output, machinery damage, restart complexities and the long term impact like profitability, long term machinery damage and other things like overall operation and status of machineries. Choice Experiment is a suitable Stated Preference approach, because respondents are able to define their preference, select suitable attributes or characteristics and choose an alternative that would maximize their satisfaction.

In this study, the anticipated change which will be introduced to the companies is an improved and reliable electricity power supply. Reliability characteristics or attributes of electricity service were derived from researchers‘ personal experience in the cement sector and by one to one discussion with other experienced professionals in the sector, cement seminars and journals, and government official documents.

The attributes are; Prior information for outages, reduction in number of outages, and reduction on duration of outages. In the discussion set up by the researcher to design the choice experiment choice sets some participants (All participants are cement sector professionals) were proposing that it is prefferable to pay extra to reduce outages or blackouts, from as little as 2.5% to as much as 10% extra from the bill they are paying at the status quo (current service).

Additionally, the professionals‘ members stated that the average numbers of blackouts occurring in a week ranged from 3 to 6, with an average duration of 3 to 8 hours. The attributes and their levels, description of the attributes and variable type, and their descriptions are presented in data collection and input section.

In a choice experiment, individuals are asked to decide on their preferred alternative from several options in an exceedingly choice set, and that they are usually asked to reply to a sequence of such choices. Identifying the attributes of the affected good/service is that the initiative in an exceedingly choice experiment. per Boxall et al. (1996), choice experiments depend on the accuracy and completeness of the characteristics and features accustomed describe the case.

The main issue is to maximize the efficiency of the survey to extract information from the respondents. Each answer to a choice set should provide additional information for the statistical model, so eventually the preferences for various levels of the attributes are individually identified. The three steps in the design development are:

1. Finding the optimal combinations of attributes
2. Combining those profiles into choice sets.
3. Group choice sets into questionnaires.

There are five stages in designing Choice experiment:

i. Selection of attributes: This is the stage where a selection of the attributes for the goods or services to be valued. In this study the service to be valued is electric power supply and the attributes are frequency of outage, duration of outage, the type of outages and additional cost is assigned as attributes to allow estimation of WTP.

ii. Assignment of levels: Achievable and practical level and range of attributes is assigned for each choice sets based on the discussion made with the sector professionals.

iii. Choice of experimental design: Statistical design theory is employed to combine the amount of the attributes into variety of different environmental scenarios or profiles to be presented to respondents. Complete factorial designs allow the estimation of the complete effects of the attributes upon choices: that has the consequences of every of the individual attributes presented (main effects_) and therefore the extent to which behavior is connected with variations within the combination of various attribute offered (interactions_).

iv. Construction of choice sets: The profiles identified by the experimental design are then grouped into choice sets to be presented to respondents. Profiles can be presented individually, in pairs or in groups.

v. Measurement of preferences: is selection of the procedure to conduct the survey and conducting the survey. In this study the survey was made by communicating the respondents through electronic means.

3.2.1.1 Design of choice sets

Correct and well-designed choice sets are presented to the respondents to make their choice and the specifications of the choice sets are as follows: The objectives of a choice set design include:

- To maximize attribute and get a reasonable and realistic view from the respondents_ perspective;
- To clearly identify and use attributes and choice alternatives that are relevant from the respondents_ perspective;
- To create and implement meaningful and acceptable, achievable and realistic tasks;
- To identify attributes, choice alternatives and tasks that are relevant from a client_s or respondents perspective; and to develop and implement tasks with appropriate advantageous properties.

The alternatives that are presented to the respondents can be either labeled. For instance the base scenario or the status quo is labeled as the current scenario and the alternatives are labeled as option A and Option B. Three numbers of alternatives are presented to each respondent in each choice set and the number of choice sets is six in each questionnaire. The number of levels for the attributes used in this study depends on

- The number of levels needed to explain the hypothetical scenario
- The size of the experimental design that one can afford
- The need to specify non-linear attribute effects.
- The choice sets which are presented to the respondents carry enough information to act upon.

3.2.1.2 Definitions of Attributes and Levels

From all the tasks in choice experiment choosing the attributes to be included in the choice set is the most important task. As we try to explain above, Attributes are identified based on a serious evaluation of all the benefits the respondents will get from the sustainable supply power and all the problems they will face when there is an interruption and a very detailed study of related literatures. Accordingly, the attributes included in the experiment should be relevant for the for the study in the consideration. For example, Frequency of outage is one of the attributes identified in this study for choice experiment and used in the study. There is high frequency of power interruption due to an overload created due to the shortage of electricity or poor networking system or other.

1. **Frequency of outages**: This refers to the average number of outages per month. In this study it is presented with three frequencies: ones a month, 3 times a month and 5 times a month.
2. **Duration of outages**: This is how long an outage lasts on average. It is presented with three durations: one hour, two hours and three hours.
3. **Type of Interruption**: Interruption with prior information and Interruption without prior information. With prior information refers to the type of outage which the electric power provider gives the information to the customer that there will be a power cut at a specific date and time. To the contrary interruption without prior information refers to a sudden power cut without prior information given to the customer. It is believed that if the customers are informed about an interruption before it occurs, they will take measures to minimize the losses. These measures include preventing the losses due to of damages to equipment‘s, spoiled materials, third party costs like delayance of orders and other costs from production losses and restart losses that will be suffered by the industrial customer.

In order to provide improved electricity services, the Government (Service provider) has to make major capital investments and cover maintenance costs and investment for new project for capacity building. The level of investment and maintenance costs required to provide a service depends on the levels chosen for each of the attributes defined above. The Government will pay for this investment, operation and maintenance costs by collecting money from the electricity users. For example, reducing the number of outages requires higher investment and maintenance costs and as a result, the tariff charged to the users will be higher.

3.2.1.3 Data Input

Once the primary and secondary data have been collected, they were entered into a computer. Excel worksheet was used and analyzed the primary data which were found on the companies records. And the choice experiment response was organized in order of the independent variables from the experimental design (attribute levels) followed by the dependent variable (what option respondents chose).

Table 3.1: Example of a choice set in the questionnaire

CHOICE SET 1

	Option A	**Option B**	**Current Service**
Frequency of outages	Three times a month	Outage twice a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	Outages for two hours	Outage for three hours	
Type of outage	With prior information	Without prior information	
Additional cost on monthly electricity bill	2.5% of average monthly bill	5% of average monthly bill	
	[ ]	[ ]	[ ]

Source: Own design

Assume option A is chosen

Table 3.2: An example of a DCE question and coding

	Option A	Coding	Option B	coding	Option (Current service)	coding
Frequency of outages	3 times	3	2 times	0	10.5	0
Duration of outages	2 hours	2	3 hours	0	6.6	0
Type of outage	With prior info.	1	With prior info.	0	Without prior info.	0
Additional cost on monthly electricity bill	2.5% of monthly bill	2.5	5% additional cost	0	0	0
I choose the option	■		□		□	

Source: Own design

As we can see on Table 3.3 the selected option will take the value which is chosen and the rejection option will take zero values. These values will be repeated for all the choice sets respondent to respondent and the chosen option from the six choice set will be selected and clarified individually.

Illustration of codding and Data input

i. **id**: it is the respondents identification and unique to each respondent. It will be the same for the first 18 rows and then the next 18 rows etc. as there are six choice sets and three options.
ii. **t**: is used to indicate which unique choice is made. Stata requires a variable indicating each unique choice made. This increases continuously for each choice.
iii. **alt**: is used to indicate the alternative within each choice set which means alt=1 represents the first alternative, alt=2 the second alternative and alt=3 represents the alternative 3 in each choice set (service A, service B and service C respectively).
iv. **Choice set**: indicates which choice was presented from the available five choices.
v. **Choice(y):** is the dependent variable, indicating respondent‘s choice of electricity service (service A, service B and c). These service alternatives take the value of 1 for the chosen alternative and zero for those not chosen.
vi. **Additional cost**: is the attribute taking the values in the dataset that correspond to the levels presented in the questionnaire. Cost was treated as a continuous but fixed variable in the regression analysis, and it was coded by taking its respective level as presented in the questionnaires.
vii. **Frequency of outages**: is a categorical attribute which shows the frequency of outage on that same choice set and option.
viii. **Duration of outages:** is a categorical attribute which shows the duration of outage on that same choice set and option.
ix. **Type of outages**: this is also a categorical attribute it is coded as a dummy variable taking 1 for an outage happening with prior information and 0 for an outage happening without prior information

Assume option A is chosen

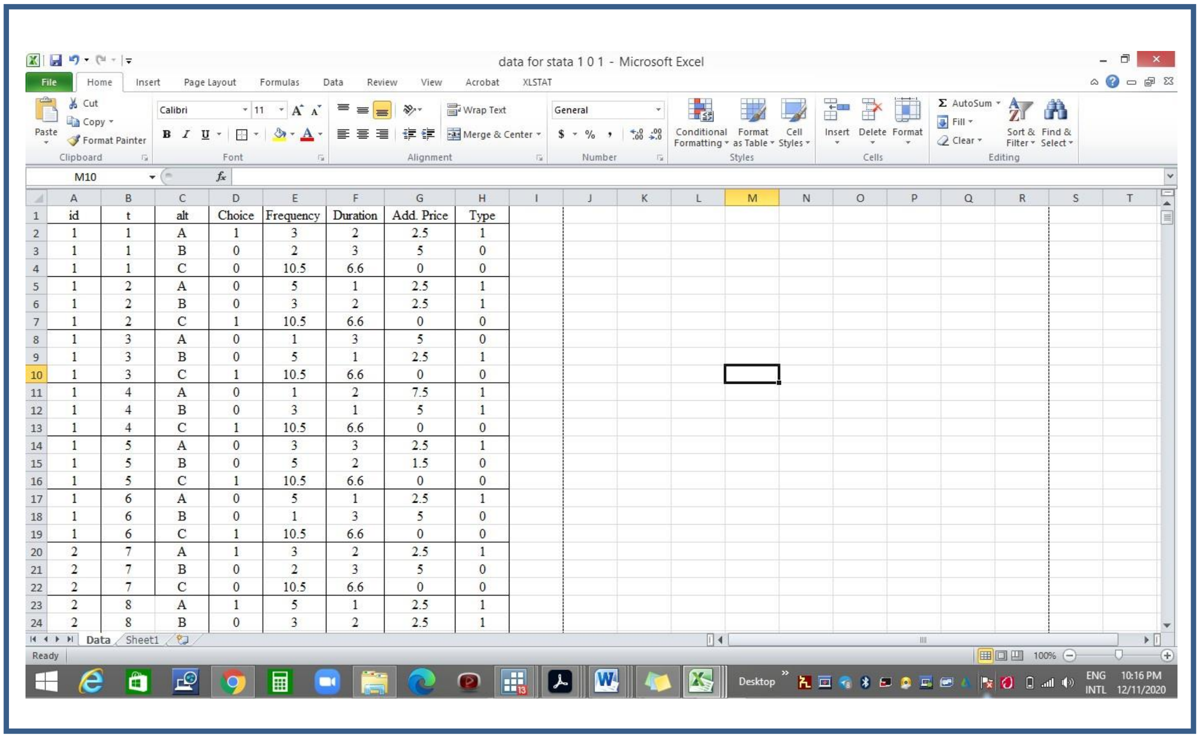
Table 3.3: An example of a DCE question and coding

	Option A	**Coding**	**Option B**	**coding**	**Option (Current service)**	**coding**
Frequency of outages	3 times	3	2 times	0	10.5	0
Duration of outages	2 hours	2	3 hours	0	6.6	0
Type of outage	With prior info.	1	With prior info.	0	Without prior info.	0
Additional cost on monthly electricity bill	2.5% of monthly bill	2.5	5% additional cost	0	0	0
I choose the option	■		□		□	

Source: Own design

As we can see on the table the selected option will take the value which is chosen and the rejection option will take zero values. These values will be repeated for all the choice sets respondent to respondent and the chosen option from the six choice set will be selected and clarified individually.

The codding is done on excel as it is shown in the following figure ....and exported to the software which we will use for the analysis.



id	t	alt	Choice	Frequency	Duration	Add. Price	Type
1	1	A	1	3	2	2.5	1
1	1	B	0	2	3	5	0
1	1	C	0	10.5	6.6	0	0
1	2	A	0	5	1	2.5	1
1	2	B	0	3	2	2.5	1
1	2	C	1	10.5	6.6	0	0
1	3	A	0	1	3	5	0
1	3	B	0	5	1	2.5	1
1	3	C	1	10.5	6.6	0	0
1	4	A	0	1	2	7.5	1
1	4	B	0	3	1	5	1
1	4	C	1	10.5	6.6	0	0
1	5	A	0	3	3	2.5	1
1	5	B	0	5	2	1.5	0
1	5	C	1	10.5	6.6	0	0
1	6	A	0	5	1	2.5	1
1	6	B	0	1	3	5	0
1	6	C	1	10.5	6.6	0	0
2	7	A	1	3	2	2.5	1
2	7	B	0	2	3	5	0
2	7	C	0	10.5	6.6	0	0
2	8	A	1	5	1	2.5	1
2	8	B	0	3	2	2.5	1

Fig 3-1: Example of how to encode the choice experiment data on excel
Source: Own data

3.2.1.4 Model Specifications and Model of Choice

This section of this study describes the models used to analyze the choice experiment. Multinomial logit model is particularly appropriate in models of choice behavior, where the explanatory variables may include attributes of the choice alternatives (frequency, duration, type…) as well as characteristics of the individuals making the choices (maximizing the benefit) but in this case individual characteristics are not taken into consideration as the study is being made on companies and the respondents will choose the choice which will maximize their companies benefit.

Suppose that Yi represents a specific choice among J alternatives. Let U_{ij} represent the value or utility of the j^{th} choice to the i^{th} individual. We will treat the Uij as independent random variables with a systematic component η_{ij} and a random component ϵ_{ij} such that

$U_{ij} = \eta_{ij} + \epsilon_{ij}$ 1

We assume that respondents act in a rational way, maximizing their company benefit and utility. Thus, subject i will choose alternative j if U_{ij} is the largest of $U_{i1},\ldots,U_{iJ}$. Note that the choice has a random component, since it depends on random utilities. The probability that subject i will choose alternative j is

$\pi_{ij}=P_r\{Y_{i=j}\}=P_r\{\max(U_{i1},\ldots,U_{ij})=U_{ij}\}$...2

$\pi_{ij} = \overline{}$ ………………………………………………………………………..…3

Equation 3 definines the multinomial logit model.

Hensher, D.A. Rose & J.M. Green, W.H.,2005 explains multinominal logit as where J=2, individual i will choose the first alternative if $U_{i1}-U_{i2} > 0$. If the random utilities U_{ij} have independent extreme value distributions, their difference can be shown to have a logistic distribution, and we obtain the standard logistic regression model. There different kinds of models which are conditional logit model, Multinomial logit Model Random Parameter logit and others each of them are explained well in the coming section.

i. **Multinomial Logits**

Usually in multinomial logit model, the maximum utilities ηij are modeled in terms of characteristics of the individuals as the following:

$\eta ij=Xi\beta j$...4

Here the regression coefficients βj may be interpreted as reflecting the effects of the individual characteristics on the odds of making a given choice.

The limitation of this model is that the same attributes Xi are used to model the utilities of all J choices. This limitation can be expressed well by different bus color ―yellow/red bus‖ problem. Suppose people have a choice of transportation between a train, a yellow bus and a red bus. Suppose half of the people take train and half take bus and further thaose who take the bus are indifferent to the color, so they distribute themselves equally between the red and the yellow buses. The choice probabilities of π= (.50, .25,.25) would be consistent with expected utilities.

Suppose now the blue bus service is unavailable. It is expected that all the people who used to take the blue bus would take the red bus instead, leading to a 1:1 split between train and bus. On the basis of the expected utilities by multinomial logit model would be a 2:1 split. (Hensher, D.A. Rose & J.M. Green, W.H.,2005)

ii. **Conditional Logits**

According to a model proposed by McFadden (1973) the expected utilities ηij in terms of characteristics of the alternatives rather than attributes of the individuals. If zj represents a vector of characteristics of the j^th alternative, then the model is postulated as

$$\eta_{ij} = z_{j}\gamma \qquad 5$$

This model is called the conditional logit model, and turns out to be equivalent to a log-linear model where the main effect of the response is represented in terms of the covariates Zj.

Note that with J response categories the response margin may be reproduced exactly using any J−1 linearly independent attributes of the choices. Generally one would want the dimensionality of zj to be substantially less than J. Consequently, conditional logit models are often used when the number of possible choices is large. (Train, 2003)

iii. **Combined Multinomial Conditional Logits**

The limitations in the above two models has been solved by combining the multinomial and conditional logit formulations, so the underlying utilities ηij depend on characteristics of the individuals as well as attributes of the choices, or even variables defined for combinations of individuals and choices (such as an individual's perception of the value of a choice). The model is written as

$$\eta_{ij} = x_i\beta_j + z_{ij}\gamma \qquad 6$$

Where xi represents characteristics of the individuals

Zij represents characteristics of the choices (whether they vary by individual or not).

Some statistical packages have procedures for fitting conditional logit models to data sets where each combination of individual and possible choice is treated as a separate observation. (McFadden and Train, 2000).

iv. **Random parameter logit (RPL)**

The RPL model is also known by the name mixed logit model (ML). The model allows the coefficient of the variables to vary randomly with a probabilistic distribution across individuals (Yang, 2005). In the RPL model, individual heterogeneity is formed by varying the different parameters in the population. Random parameters with the mean and variance are modeled by assuming that the parameters conform to a multivariate normal distribution across individuals (Lee et al., 2003), as follows*:*

$$\mathbf{Uij} = \alpha_{ij} + f(\beta_i \backslash \beta mean, \boldsymbol{\beta}_{std}) Zij + H_{ij}$$

$$= \alpha\ ij + \beta mean\ Zij + \boldsymbol{\beta}_{std} Zij + H_{ij}$$

$$= \alpha\ ij + \beta mean\ Zij + \eta_{ij} + \varepsilon_{ij} \quad \text{.......} 7$$

Where α_{ij} represents aspecific constant for individual i (i = 1… n) and alternative j (j = A, B, C).

$\beta_{mean:}$ is constant parameter in the population,

β_{man} $Z_{ij:}$ represents attributes of alternatives within a choice set.

$B_{std:}$ is an individual deviation parameter,

$\beta std Z_{ij}$ or $\eta_{ij}$is known as a stochastic component that reflects individual heterogeneity.

η_{ij} vary in the population with density $f(\eta_{ij} \backslash \Omega)$,

Ω is the existing parameter distribution.

$f(\eta_{ij} \backslash \Omega)$ takes on different distributional forms such as normal, lognormal, uniform or triangular,

ε_{ij} is a random term across alternatives and individuals.

(Lee et al., 2003, Grosjean and Kontoleon, 2009).

For a given value of η_{ij}, the conditional probability of individual i choosing alternative jin a choice set in a standard logit, is:

$$pi(j/\eta ij) = \frac{}{\Sigma} \quad \text{....................8}$$

However, the individual tastes are commonly unknown. Hence, it is necessary to calculate the unconditional probability generated from the equation above across all possible values of ηij.

This can be expressed as:

$$pi(j/\eta ij) = \int \frac{}{\Sigma} \int \quad \text{....................9}$$

The utility function in the RPL model estimated from the above equation can be expressed as:

Vij = ASCj+ st 10

Where Zij represents a vector of ecosystem restoration attributes of an alternative j (j = A, B, C) within the choice sets, k attributes,$\beta_{mean\ j}$ is the vector of coefficients of these attributes, β_{mean} is the vector of standard deviation parameters or random parameter. The experiment in this sample is unlabeled or generic where the options provided to respondents are unbranded. For generic or unlabeled formats, respondents can not associate the options to any specific programme, that is to say they are unable to brand the alternatives available; however they can identify the current service from the given new options. (Hensher et al., 2005)

$V_{ij} = B_1$ Cost + B_2 Frequency + B_3 Duration+ B_4 Type of outage 11

The selection of the choice model in this study is the steps recommended by Hensher et al.(2005) to estimate the conditional logit models, with all parameters of attributes except the cost parameter initially considered as random parameters.

3.2.2 Marginal Willingness to Pay and Willingness to Pay

3.2.2.1 Marginal Willingness to Pay

In a linear statistical model, the β coefficients estimated under the MNL model can be used to estimate the rate at which respondents are willing to trade-off one attribute for another. The tradeoff estimated is known as ‗marginal willingness to pay‘. Which is the amount of money respondents are willing to pay to receive the maximum of the non-marketed environmental attribute: (Hensher, D.A. Rose & J.M. Green, W.H.,2005)

Marginal Willingness to pay= - (β non-marketed attribute⁄ β monetary attribute)............ 12

According to Bennett and Blamey (2001) Estimates of implicit prices are made on a ‗ceteris paribus‘ basis-that is, they are estimates of the willingness to pay of respondents for an improvement of the attribute of concern, given that everything else is same., The principles applying to the determination of MWTP can also be applied to derive the willingness to exchange between any pairs of attributes. Hence, by division of β coefficients, the marginal rates of substitution across all the attributes, monetary and non-monetary, can be estimated. Such estimates may be useful for policy implementation of the service improvement that restore community well-being, not necessarily by the payment of financial compensation for power losses. The implicit prices are useful in that they demonstrate the trade-off between individual attributes. A comparison of the implicit prices of attributes affords some understanding of the relative importance that respondents hold for them.

Based on such comparisons, policy makers are better placed to design improved service alternatives to favor those attributes, which have higher (relative) implicit prices.

3.2.2.2 Willingness to pay

Consumer surplus or mean WTP:-the amount of money (given or taken away) that make a person as well off, as they would be after a change. It represents the amount of money that individuals‘ are willing to compensate to get improved electricity services.

3.2.3 Description Software Used

Stata is a powerful statistical software that enables users to analyze, manage, and produce graphical visualizations of data. It is primarily used by researchers in the fields of economics, biomedicine, and political science and other fields to examine data patterns. It has both a command line and graphical user interface making the use of the software more intuitive.

The tools in stata gives control over raw data and datasets. Users can import or export their data from a local or online source. It works with standard databases. The software has an integrated spreadsheet for basic data input. Users can work with text or binary data. They can enter and incode with Unicode.(Stata website)

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1Emperical Result and Discussion

4.1.1 Outcome of Data Analysis Using Descriptive Statistics

Descriptive analysis results shows that among the sample of respondents 86% were technical persons with 11years of average experience in the sector and the remaining 14% were financial personels with 18years average experience.

Table 4.1: Respondent Profile

	Frequency	Percentage
Highest academic qualification		
Diploma	2	1.19
First Degree	135	80.36
Postgraduate qualifications	31	18.45
Over Post Graduate Qualification	0	0.00
Academic Field		
Engineering	122	72.62
Other Science field	25	14.88
Finance	10	5.95
Management	11	6.55

Work Experience in cement		
1-5Years	30	17.86
5-10Years	48	28.57
10-15Years	80	47.62
Over 15Years	10	5.95
Job Position in the Company		
Senior Manager/GM/CEO	6	3.57
Department heads	35	20.83
Division heads	102	60.71
Department staff	25	14.88

Source: Own survey

As can be seen from the above table it can be concluded that the respondents have the required education level, experience and understanding of the sector and the problem under investigation and the result can be taken without hesitation for any conclusion from this outcome

4.1.1.1 Perception of Electricity Tariff

Even though Ethiopia is regarded as one of the top 10 countries in the world with lowest electric power according to Doing business data base 20.8% of the respondents believe that the tariff is high compared to the service being provided

Table 4.2: Summary of the respondent‘s perceptions on the price of electricity.

Category	Price of electricity(%)
Very high	20.8
High	16.7
moderate	42.3
Low	15.4
Very low	4.8

Source: Own survey

4.1.1.2 Disruptiveness of the Time of outage

The respondents were asked when is unplanned outages of uncertain duration most disruptive Daytime or Nighttime?

Table 4.3: Summary of the respondent‘s perceptions towards disruptiveness

Category	Price of electricity
Day time	9.6
Night time	60.1
Both equally likely	30.3
None	0

Source: Own survey

4.1.1.3 Attitudes to the current Electricity Service

The respondents‘ attitudes to the electricity system had summarized as follows. The power supply provided by the electric company perceived 100 percent as fair and below it is perceived poor or very poor by 89.7% of the respondents, 10.3% perceived as fair

19.2 % of the respondents strongly agree or agreed with the statement that their power supply had improved in the last 5 years on the other hand 31.2% agree or strongly agree that the electricity service has improved in the last 2 years 47% is neither agree nor disagree with the statement that the electricity power supply is improved in the last 5 years and 22% statement.

However, 58.8% of the respondents disagreed or strongly disagreed with the statement of it has improved in the last five years to the contrary only 21.8% of the respondents disagreed or strongly disagreed with the statement of it has improved in the last five years.

If during peak periods, the utility company asked its customers to reduce their electrical consumption for a period of 2 to 4 hours, 47.75% of the respondents would be willing to reduce their electrical consumption while 26.13% of the respondents would not be willing to reduce their electrical consumption and the remaining 26.13% are argue that they may be willing to reduce their electrical consumption.

Table 4.4: Perception of respondents towards effect of power interruptions.

	Frequent power interruption		
	leads the cement companies to loss	Pushes out new investments from the sector	Leads the country to cement shortage

Strongly agree	57.74	19.64	67.26
Agree	31.54	21.43	21.43
Neutral	6.55	49.40	8.93
Disagree	4.17	4.17	2.38
Strongly disagree	0	5.36	0

Source: Own survey

4.1.1.4 Frequency versus Duration of Unplanned Interruptions

96.4% respondents strongly agree or agree with the question that says frequent short interruptions are much worse than one long interruption.

Table 4.5: Frequency versus duration perception

Frequent short interruptions (30 minutes or less) are worse than one long interruption (more than 30 minutes). E.g., four 30-minute interruptions in a day are worse than one 2-hour interruption.	Response	Percentage
Strongly agree	130	77.38
Agree	32	19.05
Neutral	4	2.38
Disagree	2	1.19
Strongly disagree	0	0

Source: Own survey

4.1.2 Damage cost of power outage

50% of the respondents argue that their company faced damage of equipments resulting from abnormal power release. While the other 50% of them did see their company suffered damage of equipments resulting from abnormal power release.

4.1.2.1 Preferred Interruption Type and time for Unplanned Outages

100% of the respondents preferred long outage with prior information than shorter one without prior information and 65% of the respondents believe that night time outages are most disruptive than day time 31% of them said it doesn‘t matter what time will happen the outage on the disruptiveness and 4% believe it is disruptive when it happens in day time.

4.1.3 Discussion of Descriptive analysis

In this chapter we elaborate on methodical aspects of modeling economic losses in the event of widespread blackouts and explain their significance for the interpretation of the figures for such losses. To do this, possible losses due to electricity outages need to be classified. The economic aftereffects can be divided into three categories: (Bennett and Blamey, 2001)

· Direct costs
· Indirect costs
· Resulting long-term costs

In the public eye direct economic losses are usually at the top of the list. Of the total economic losses they are the part which is a direct result of the failure, These classification can be categorized with lei man terms as loss due to spoiled materials, loss due to output lost, loss due to idle manpower, loss due to damaged equipment and restart cost.

4.1.3.1 Loss due to spoiled materials

The chemical reactions required to make cement occur in the cement kiln before getting the final output of the kiln there are a lot of intermediate products in the operation. The reactions in the kiln are occurring in an elevated temperature and any power interruption will cause the reactions to be interrupted and the process will be disturbed during this time the material in process will be spoiled. Whenever the power resumes it will take some time to stabilize the process and to get the required quality of material.

4.1.3.2 Loss due to lost output

The impact of a power failure on production time lost can be much longer than the duration of time of the power failure itself. So, in order to calculate total production time lost, one needs to add the extra time needed to restart the production after a power failure to the duration of that power failure.

Power outages causes huge economic loss due loss of sales revenues revenue. Some of companies fixed expenses are not changing weather the company is producing or not so these expenses has to be compensated by sales and power cuts will hinder the companies from sales and this is the result of loss of output specially for products that are always in shortage like cement.

Table 4.6: Estimation of loss of output due to power outrages

S.no	Year	Lost hr.	Capacity (tph)	Lost output (ton)	Average cement price	Lost Revenue
Mugher	2016	210.20	210	44,142.00	210	9,269,820
	2017	81.52		17,119.00	210	3,595,032
	2018	48.30		10,143.00	270	2,738,610
	2019	620.40		130,284.00	270	35,176,680
Dangote	2016	864.33	210	181,509.00	210	38,116,953
	2017	67.82		14,242.00	210	2,990,862
	2018	34.67		7,281.00	270	1,965,789
	2019	545.22		114,496.00	270	30,913,974
National	2016	89.76	142	12,746.00	210	2,676,643

	2017	121.68		17,279.00	210	3,628,498
	2018	92.67		13,159.00	270	3,552,968
	2019	737.27		104,692.00	270	28,266,932
Habesha	2016	257.12	125	32,140.00	210	6,749,400
	2017	111.24		13,905.00	210	2,920,050
	2018	86.70		10,838.00	270	2,926,125
	2019	632.18		79,023.00	270	21,336,075
Deraba	2016	100.25	210	21,053.00	210	4,421,025
	2017	41.85		8,789.00	210	1,845,585
	2018	79.29		16,651.00	270	4,495,743
	2019	724.29		152,101.00	270	41,067,243

Source: Own survey

4.1.3.3 Loss due to idle manpower

During an outage, an enterprise has two options: suspend the production till the power is restored; or, invest in mitigating equipment (e.g., installing generators) and produce as planned. If net selling revenues that could have been generated during outages are sufficient to cover variable operating costs and the costs of re-starting production from its idle mode, investment in mitigation strategies may become economically viable. In case of cement plants (In our case the factories require 30-45MW of owner) where their power consumption is high investing in standby generators is too high to consider.

Idle time is paid time that an employee, or machine, is unproductive due to factors that can either be controlled or uncontrolled by management. Idle time can be classified either as normal or abnormal.

Big cement plants pay approximately 90birr per ton of cement for labor, this value might be higher for small capacity cement plants (According to cement seminar 2019 booklet) which means the cement plants pays this much weather the companies are producing or not.

Table 4.7: Estimation of loss due to idle workers.

S.no	Year	Lost hr.	Design Capacity (tph)	Lost output (ton)	Labor expense per ton of cement	Lost Revenue
Mugher	2016	210.2	210	44,142.00	90	3,972,780
	2017	81.52		17,119.00	90	1,540,710
	2018	48.3		10,143.00	90	912,870
	2019	620.4		130,284.00	90	11,725,560
Dangote	2016	864.33	210	181,509.00	90	16,335,810
	2017	67.82		14,242.00	90	1,281,780
	2018	34.67		7,281.00	90	655,290
	2019	545.22		114,496.00	90	10,304,640
National	2016	89.76	142	12,746.00	90	1,147,140
	2017	121.68		17,279.00	90	1,555,110
	2018	92.67		13,159.00	90	1,184,310

	2019	737.27		104,692.00	90	9,422,280
Habesha	2016	257.12	125	32,140.00	90	2,892,600
	2017	111.24		13,905.00	90	1,251,450
	2018	86.7		10,838.00	90	975,420
	2019	632.18		79,023.00	90	7,112,070
Deraba	2016	100.25	210	21,053.00	90	1,894,770
	2017	41.85		8,789.00	90	791,010
	2018	79.29		16,651.00	90	1,498,590
	2019	724.29		152,101.00	90	13,689,090
					Total	90,143,280

Source: Own survey

As can be seen from the above table the five companies lost a total of 90 million birr over the course of four years Dangote cement being the highest victim with a loss of more than 28 million birr Mugher comes next with 18 million and the lowest loss due to idle manpower registered by Habesha just over 12 million birr.

4.1.3.4 Loss due to damaged equipment

Cement factory equipment‘s are sequential and interlocked each other and it‘s not easy to restart even after power resumed. In addition to the loss due to output loss in some cases it results in equipment damage in two ways. The first one is a damage in the kiln refractories due thermal stress when temperature changes and the second one is due to a voltage fluctuation when the power resumes equipment‘s or their protection will get damaged.

After a large number of experimental studies on the refractory materials and the statistics of the main causes of refractory damage are: mechanical stress accounted for 37%, due to deformation of the cylinder and thermal expansion of the brick; chemical erosion accounted for 36%, due to cause by the erosion of clinker silicate and alkali salt; thermal stress accounted for 27% due to overheating and thermal shock. Stable production operations should be established and a reasonable heating and cooling kiln system should be established. (Gadayev, A., and Boris K.,1999)

With the different types of kiln, operation and kiln lining in the kiln, the above three factors play different roles, mainly depending on the deformation state of the flame, kiln material and kiln cylinder during operation like frequent start and stop of plant of the kiln. The lining is subjected to a variety of different stresses. (Gadayev, A., and Boris K., 1999)

4.1.3.5 Restart costs

Cement kilns require temperatures to reach and be maintained at 2000 degrees or higher so any power cut will result in immediate drop in these temperatures and affect the product quality. In addition to the problem in product quality restarting the kiln and reaching the required temperature after power resumed will take some time and will cost the company the fuel and other electric power cost without any output at this heating up process. At the same time when there is a power cut the kiln will be cooled down procedurally to avoid thermal stress.

4.1.3.6 Effect of power outage on Productivity

Productivity represents the amount of output per unit of input. Labour productivity decreases due to a decrease in efficiency in the use of labour or due to a forced idleness of labor due to lack of inputs. One of the inputs in the production of cement is electric power which means any stoppage in electric power will result in decrease in productivity. Productivity is the ratio of output to input. Assuming everything is available to operate the plant and the workers are 100 % engaged in the work the manhours available for running the plant per year is 365*24= 43,800hrs

Labour productivity based on lost production hours for each companies is tabulated below

Table 4.8: Estimation of plant productivity

Company	Productivity			
	2016	2017	2018	2019
Mugher	99.52	99.81	99.89	98.58
Dangote	98.03	99.85	99.92	98.76
National	99.80	99.72	99.79	98.32
Habesha	99.41	99.75	99.80	98.56
Derba	99.77	99.90	99.82	98.35

Source: Own survey

The table shows the productivity decrease only by power outages ranges from 0.2% to 2%

4.1.3.7 Effect of Power outage on Plant performance

There are different methods to measure the Overall equipment efficiency (Overall equipment performance) the well-known ones are Availability and performance, De Groote (1995)

Availability (A) = ______________________________

Performance (P) = ____________________

The values of the above parameters are tabulated below

Table 4.9: Estimation of plant availability and performance

S.no	Year	Planned production time. Hr	Unplanned down time hr.	Planned Production	Lost output (ton)	Actual production	Availability	Performance
Mugher	2016	7920	210.2	1663200	44142	1619058	97.3	97.3
	2017	7920	81.52	1663200	17119	1646081	99.0	99.0
	2018	7920	48.3	1663200	10143	1653057	99.4	99.4
	2019	7920	620.4	1663200	130284	1532916	92.2	92.2
Dangote	2016	7920	864.33	1663200	181509	1481691	89.1	89.1
	2017	7920	67.82	1663200	14242	1648958	99.1	99.1
	2018	7920	34.67	1663200	7281	1655919	99.6	99.6

	2019	7920	545.22	1663200	114496	1548704	93.1	93.1
National	2016	7920	89.76	1124640	12746	1111894	98.9	98.9
	2017	7920	121.68	1124640	17279	1107361	98.5	98.5
	2018	7920	92.67	1124640	13159	1111481	98.8	98.8
	2019	7920	737.27	1124640	104692	1019948	90.7	90.7
Habesha	2016	7920	257.12	990000	32140	957860	96.8	96.8
	2017	7920	111.24	990000	13905	976095	98.6	98.6
	2018	7920	86.7	990000	10838	979162	98.9	98.9
	2019	7920	632.18	990000	79023	910977	92.0	92.0
Deraba	2016	7920	100.25	1663200	21053	1642147	98.7	98.7
	2017	7920	41.85	1663200	8789	1654411	99.5	99.5
	2018	7920	79.29	1663200	16651	1646549	99.0	99.0
	2019	7920	724.29	1663200	152101	1511099	90.9	90.9

4.2 Choice Experiment Result and Discussion

In this survey, choice set includes three alternatives including statuesque option so a conditional logit is preferred for capturing the taste preferences amongst respondents.

```
. clogit Choice Frequency Duration AddPrice Type, group(t)
note: multiple positive outcomes within groups encountered.
note: 26 groups (444 obs) dropped because of all positive or
      all negative outcomes.

Iteration 0:   log likelihood = -899.59409
Iteration 1:   log likelihood = -899.39734
Iteration 2:   log likelihood = -899.39733

Conditional (fixed-effects) logistic regression   Number of obs   =       1574
                                                  LR chi2(4)      =     122.18
                                                  Prob > chi2     =     0.0000
Log likelihood = -899.39733                       Pseudo R2       =     0.0636

------------------------------------------------------------------------------
      Choice |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   Frequency |   -.152811    .048361    -3.16   0.002    -.2475969   -.0580252
    Duration |  -.0119983   .0657756    -0.18   0.855    -.1409161    .1169194
    AddPrice |   -.091186   .0593702    -1.54   0.125    -.2075494    .0251773
        Type |   .3528379   .1925289     1.83   0.067    -.0245117    .7301876
------------------------------------------------------------------------------
```

Fig 4.1: Screen shot of the STATA data analysis output

Source: Own Data analysis

Fig 4.1 shows the results of the conditional logit model, which indicates that, the attributes such as Frequency of outages, type of outage (with prior information) and cost attribute is significant and that is shown by a small p-value. In addition, the mean coefficients of the attributes such as frequency of outage, duration and additional cost are negative and type of outage (With prior information) is positive which as expected. From the above positive and negative signs we can conclude that negative sign of frequency and duration shows that the companies prefer fewer outages and durations, the positive sign of type of outages shows they prefer the outage to be a pre-informed outage. For the cost attribute, this coefficient is negative, because the utility of selecting an increase in service reliability decreases with higher payments.

A higher negative value of the coefficient of a specific attribute shows that a small adjustment in that attribute will have a greater impact in maximizing the utility. In our result the highest negative is found on duration which means a higher increase in satisfaction will come on a small decrease in frequency. For the cost attribute, this coefficient is negative, because the utility of selecting an increase in service reliability decreases with higher payments.

The marginal WTP for a certain attribute given our assumptions about a linear income effect is the ratio of the attribute coefficient and the marginal utility of income (Hanemann, 1984), where the coefficients for the cost attribute is interpreted as the marginal utility of money. The results indicate that the highest marginal willingness to pay is for the Frequency of outage attribute as they expect that reduction in frequency of outage will reduce the extra costs they will incur in heating up of the kiln, equipment damage in during resumption of power in general they will reduce the tedious restart process and cost.

The other thing we see from the result duration is the last thing they care from all the independent variables (attributes). When it comes to the type of outage the companies believe that if the outage is a pre-informed outage it will help them in procedurally stopping their plant equipment and also help them in planning any maintenance activity and planning on their manpower.

4.2.1 Marginal Willingness to pay and willing ness to pay

To calculate the willingness to pay first we have to calculate the utility associated with the current option and the option being considered. Using the mixed logit model, this is achieved by substituting the model coefficients and the attribute levels for the current option. The value of the utility of the alternative option is estimated in a similar way. The change from the status quo to the new scenario is then estimated by calculating the difference between these two values, and multiplying this by the negative inverse of the coefficient for the cost attribute.

V_{ij} =B1 Cost + B2 Frequency + B3 Duration+ B4 Type of outage................................. 11

WTP = – 12

Where, Vo and V1 represent the initial and subsequent utility states respectively. The model also enables the estimation of welfare changes (compensating surplus) associated with an array of changes in service quality of the electricity away from th “st tus quo” sc r o curr t s tu t o .

By taking the coefficients from the regression analysis the utility for the status quo is

The marginal WTP for a certain attribute is the ratio of the attribute coefficient and the marginal utility of income (Hanemann, 1984), where the coefficients for the cost attribute is interpreted as the marginal utility of money. Using the coeffcients fro the regression analysis we will get the following result.

Table 4.10: Mean willingness to pay

Attribute	MWTP
Frequency	1.67581
Duration	0.13158
Type of outage	3.86943

Source: Own survey

Willingness to pay will be calculated as follows

Current situation/ status quo scenario

- High frequency of outages(10.5 per month)
- Duration of outage (6.6 hrs/outage)
- There is no prior information(the outage that occur any time)

Improvement scenario 1

- Frequency of outage per monthly (9.5 per month)
- Duration of outage (5.6hrs)
- There is a prior information (outage occur with prior information for customer)
- Cost (there will be an increase 2.5% from the current payment)

Estimates of Willingness to pay are calculated using the above equation (Eq.12); to use this equation for estimating compensating surplus it is first necessary to calculate the utility associated with the current option and the option being considered. Using the mixed logit model, this is achieved by substituting the model coefficients and the attribute levels for the current option.

The value of the utility of the alternative option is estimated in a similar way. The willingness for the change from the status quo to the new scenario is then estimated by calculating the difference between these two values, and multiplying this by the negative inverse of the coefficient for the cost attribute.

Estimates of willingness to pay for scenario 2 are presented in Table….. These are the marginal estimates, showing willingness to pay for a change from the current situation. It can be seen from the estimates that, the WTP for the change from the status quo to the scenario considered increases as we move towards improved electricity services.

The utility is as follows as follows:

V_o = -1.77489028

V1 = -1.61236063

The WTP for to reduce the frequency of outage by 1, a 1 hr. reduction in the duration of outage and to give prior information before the outage from the status quo is tabulated under in Table 4.8.

Table 4.11: Willingness to pay

Attribute	WTP
Frequency	1.07
Duration	13.3
Type of outage	0.5

Source: Own survey analysis data

As can be seen from Table………. the companies are willing to pay 1.07% additional cost for a reduction of frequency of outage by 1 and willing to pay 13.3% more for a reduction of the duration by 1hr. and 0.5% more payment for a prior notification before the outages

4.3 Solution Approaches and Alternative Options to cope with the Problem

As discussed in the above sections the cement sector as a whole and the case companies in specific are highly challenged by the frequent power interruption and one of the objectives of this research is to give a solution approach for the problems they faced. The above section shows that the companies are willing to pay extra to secure a more reliable power supply. Once its known the problem is severe and the possible solutions are anticipated it is necessary to make a decision Matrix to point out the best possible solution.

In the decision matrix to choose the best possible solution or solutions selected cement sector professionals who were involved in the questionnaire stage were communicated back the outcome of the data analysis and were asked with one to one interview what they consider the possible factors to implement any solution which is to be proposed and then factors they come up with are: Operational cost, Investment cost, reliability, nature of solution Internal/external solution and time needed. After identifying these factors they were asked to put them in order of their importance and it was found operational cost and Investment cost are the most important factors respectively which are decisive factors for the profitability of the firm and achievability of the solution. Reliability, nature of solution Internal/external solution, time needed are the other factors but they are not as important as the first ones so they receive a lower weighted score with respect to their order.

From literature survey and data analysis the possible solution for the power interruptions are: Install backup generator for complete plant, get Insurance, plan maintenance during interruptions, change service provider, deal with the government to improve the service, Install backup generator for sensitive area (Kiln), install dedicated line for the company. Table 4:11 shows all the solutions the weighted score and the final score of the solutions.

Table 4:12 Decision Matrix of the proposed solutions

Factors	Investment cost (Lower is better)	Operational Cost (Lower is better)	Reliability (Higher is better)	Nature of Solution (Internal is better)	Time needed (Lower is better)	Score
Weight	4	5	3	2	1	
Install Backup Gen for complete plant	0	0	5	5	3	26
Insurance	3	4	5	5	5	62
Plan Maintenance	5	5	3	5	5	69
Change service provider	0	0	0	0	0	0
Deal with the Government To improve the service	3	5	1	3	3	49
Install Back up for sensitive area (Kiln)	3	1	5	5	3	43
Install Dedicated line for the company	1	5	3	0	0	38
Install protection for sensitive electronics	4	4	5	5	4	64

From the above decision matrix table we can easily see that the best solution with the highest score is to plan and do maintenance activities during the interruption and the next two solutions with the highest score are install protection for sensitive electronics equipments and Insurance for loss of revenue due to interruption.

It is a little bit difficult to compare the results of this study to other studies as there is no much similar study with this study because the sectors to be assessed are of different characters as this study focuses on manufacturing sector especially cement manufacturing sector and the studies available are most of them for household and small scale industries. But, the result of this study does not seem far from those of preceding somehow resembling studies. For example, Toleshi wakjira, 2016 showed that the customers are aware of the impact and in they are willing to pay additional 19cents per kwh for reducing the frequency and 13 cents for reducing the duration which is estimated to be about 15% additional payment per kwh and in our case the companies 1.07% additional cost for a reduction of frequency of outage by 1 and willing to pay 13.3% more for a reduction of the duration by 1hr. and 0.5% more payment for a prior notification before the outages a study by Abdullah and Mariel concluded that a Kenyan customer is willing to pay USD 0.77 to 1.35 to improve the service and in the Netherlands the willingness to pay would be EUR 10.4 to 20.8 per year. Reichl et al. study showed that the mean WTP to avoid a 24-hour electricity outage amounts to EUR 17.3 in the household sector in the Netherlands. In the United States to avoid an 8-hour blackout that could occur once a year as USD 60.

CHAPTER FIVE

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

In Ethiopian no proper attention is given to the cement factories in specific and heavy industries as a whole about the problem they are facing whenever there is anoutage and the service provider is not taking it serious and it is treating the problem as any other commercial and residential customers..

Based on the outcome of this study, we empirically conclude that there exists and significant impact of power outages on cement plants and the companies are suffering from power outages that are both frequent, long duration, and without any prior notice which makes it difficult to plan and undertake production activities and also leading them to unnecessary loss due to the power outage. Thus, understanding the cost for firms associated with an unreliable electricity supply is important for the firms to design a solution to cope with this problem and for policy makers and service providers to decide on how this problem at least to minimize the damage. The policy makers can make further study how much should and can the customers pay to change the status quo and invest that amount on electric generation and distribution infrastructure to improve the situation.

Apart from the customers the power supplier is also losing from these interruptions. The power supplier should make a detailed study about the revenue loss from the unsupplied electric power as the power is already generated but not delivered to the customer.

Previous studies have used different approaches to estimate the cost of outages for residential houses others researchers can combine this and other studies to investigate the matter and make a decision as country.

Many small firms and service sectors like commercial building and hotels are using backup generators but when it comes to cement plants as they are using a huge amount of power to operate by backup generators as the investment and the operation cost is high.

A detailed and comprehensive analysis of the issue is lacking for Sub-Saharan Africa, where unreliable electricity service is among the major reasons preventing economic growth. This paper contributes to this issue by estimating the cost of outages for cement plants and a conclusion can be drawn for other sector heavy Industry.

5.2 Recommendations and Future work

- Research institutes (Governmental and Non-governmental) can make further studies and propose to the government and electric power provider to improve the quality of the service being given and compensate the investment by charging the customer as the outcome of this research shows that the customers are willing to pay extra to get a better and reliable electric power supply.
- As it is seen in other sectors Monopoly owned business are not as good as a business scenario where there is a competition so the government should consider introducing a new service provider at least for the electric distribution sector. The government should continue on working on power generation rather than owning all the power generation and distribution.
- The study shows that the cement industries are not adaptive to power outages and they are highly affected so the government should design a support mechanism by giving tax breaks, subsidies or other protection mechanism if the problems cannot be solved in a shorter period of time.
- As this study and other studies shows it is difficult to cover the power demand for a cement plant by a backup generator or any other means the cement factories but at least the power cut can be minimized by avoiding a simple technical problem from causing a longer power stoppage.
- The service provider should provide a dedicated power line for the big industrial users which will avoid an overload due to unexpected high power usage from the public especially during holidays and weekends and should assign a well-equipped staffs to address the problem whenever there is one.
- The government should introduce a new check and balance mechanism in improving the service. As the service provider is charging the customer if the customer failed to use the power supplied/requested it should also work for the service provider by setting maximum allowable time limits for a single interruption event and set the highest frequency of interruption per month and set various penalties to the service provider and compensate the customer based on the extra hours which passed the allowable limits.
- As the cement factories are becoming more in no. and they have a cement producers association they should work on how they can guarantee their power demand reliability and also they should guarantee a bigger say and a priority whenever there is a power shortage in the country.
- As the study shows the factories are willing to pay extra for an improved electricity service they should propose to the service provider the give and take mechanism to pay more and get a better reliable service.

- The cement factories can also propose to insurance companies to have coverage for unexpected power cut and for any damage coming from such situations (This method is common in Finland and other Scandinavian countries).
- As the problem is deep rooted it cannot be addressed by individual cement factories so they should address it as a group through their association.
- The factories should always have a second plan what should they do during power cuts; like planning a maintenance work during that time to avoid the loss due to idle manpower and other tasks.
- The factories should have a protection mechanism for their sensitive electronic equipment‘s as this will avoid the damage due to damaged equipment‘s
- To think and plan to have a backup generator for the most affected section which is the kiln (Furnace) section where there is a loss due to cold furnace during the power cut?
- This study can be extended to other industrial sector like steel, chemicals food, service and other sectors.
- A comparative analysis can be performed between Ethiopia and other nearby countries in the sub Saharan region.

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APENDIX A: QUESTIONAIRE

QUESTIONNAIRES FOR SELECTED CEMENT FACTORIES IN ETHIOPIA

INTRODUCTION

My name is Tamrat Birmeta and I came from Bahirdar University and I am on a process of doing my MSc thesis on Impacts of power outages on cement industries and willingness to pay for improved electricity service in the case of selected cement industries in Ethiopia. I want to collect survey data related to electricity service.

Dear respondent,

Your participation in the survey is solely voluntary. Your participation and opinions are valuable for the success of this study. You have been selected for this independent survey because you are working in one of the cement factories where the case study is being conducted. The results will be used to recommend the possibilities to a give a sustainable electric power supply to improve efficiency and productivity, as well as in setting the appropriate tariff that reflect opportunity costs once the best alternatives are chosen. Your answers to this questionnaire will be completely confidential.

Operation manager, head of production and technique department, electric department division managers and research and development managers, Engineers from all departments are considered to complete this survey. Please answer the questionnaire by considering the overall impact of the outage on the company. There is no right or wrong answers-we are interested in your opinions. Your answer will be strictly confidential. The questionnaire consisted of three parts:

i. General information about the firm
ii. Detailed questions related to firms, and
iii. The choice experiment.

It is anticipated that it would take no more than 20 minutes to complete the questionnaire.

Consent to participate in this study is implied by completing the questionnaire.

Thank you!

PART 1: RESPONDENT CHARACTERISTICS

1. Name of the company you cover in this survey…………………………………….
2. Position in the firm……………………………………….......………………..

3. Educational level…………………………………………………………………
4. Experience……………………………………………………………………..…
5. Time in this company……………………………………………………………….
6. Have you ever worked in other companies in the same sector……………………
   If there are any how many…………………………………

PART 2: PREFERENCE AND PERCEPTION QUESTIONNAIRES

At present Ethiopian Electric Power OR Ethiopian Electric Utility is a sole provider of electric power. However, there are reliability problems, such as, the present number of unannounced outages (or blackout) which 84 times per month, with a time of two hours per outage (or blackout). Accordingly, your company should be incurring additional cost on other alternative energy sources such as Diesel Generator or loses its income by the downtime due to this stoppage.

For electricity system overall what is your opinion on the following matters? Choose, the answer, which best describes your opinion for each of the Following

1. In general, the power supply provided by electric power company is
   A. Very good B. Good C. Fair D. Poor E. Very poor
2. Did the power supply improved in the last 5 year
   A. Strongly agrees B. Agree C. Neither agree nor disagree (Neutral) D. Disagree E. Strongly disagree
3. I think that the price of electricity in Ethiopia is
   A. Very low B. Low C. Moderate D. High E .Very high
4. If during peak periods (specially holidays), the utility company asked its big industrial customers to reduce their electrical load for a period of 2 to 3days, would your company be willing to reduce its electrical load if it is not made obligatory.
   A. Yes B. No C. May be

5. If during electric rationing periods (when there is less electric generation than demand due to less water in the dams), the utility company asked its customers to reduce their electrical consumption for a period of 2 to 3months, would your company be willing to reduce its electrical consumption if it was not obligatory.

   A. Yes B. No C. May be

6. Frequent electric interruption is leading the cement companies to loss.

   A. Strongly agree B. Agree C. Neither agrees nor disagrees (Neutral) D. Disagree E. Strongly disagree

7. Frequent electric interruption is leading new big industrial investors (new cement companies in this case) rethink about their investment.

   A. Strongly agree B. Agree C. Neither agrees nor disagrees (Neutral) D. Disagree E. Strongly disagree

8. Prolonged Electric interruption is leading the country to cement shortage

   A. Strongly agree B. Agree C. Neither agree nor disagree (Neutral) D. Disagree E. Strongly disagree

9. Sustainable Electricity supply reduces workers workload.

   A. Strongly agree B. Agree C. Neither agree nor disagree (Neutral) D. Disagree E. Strongly disagree

10. Sustainable Electricity supply can increase the efficiency of a company in a significant level.

    A. Strongly agree B. Agree C. Neither agree nor disagree (Neutral) D. Disagree E. Strongly disagree.

11. Frequent Electricity interruption is one of the top three challenges the cement companies at this moment.

    A. Strongly agree B. Agree C. Neither agree nor disagree (Neutral) D. Disagree E. Strongly disagree

12. Uninterrupted power supply will solve the cement shortage in the country by a significant amount.

    A. Strongly agree B. Agree C. Neither agree nor disagree (Neutral) D. Disagree E. Strongly disagree

13. Does your company usually uses the time of outage to do other works that needs plant shutdowns like maintenance work.

    A. Yes B. No.

14. Does your company for any reason extend the plant stoppage after power is retrieved?

    A. Yes B. No

15. Frequent short interruptions (30 minutes or less) are worse than one long interruption (more than 30 minutes). E.g., four 30-minute interruptions in a day are worse than one 2-hour interruption.

    A. Strongly agree B. Agree C. Neither agree nor disagree (Neutral) D. Disagree E. Strongly disagree

16. Apart from electricity from the current provider (Ethiopian electric power), approximately how much estimated cost do you think your company incurs for alternative power source per month in average ------------------ --.

17. Apart from the cost your company incurs for alternative power source per month in average what do you think is the cost of production loss of your company during the outage.?........................

18. Apart from the cost incurred for alternative power source and production loss is there any loss due to material in process during the outage?

    A. Yes B. No

19. If the answer is yes for the above question what is the estimated cost for a 1 time power outage for 1hr duration?...

20. When is an unplanned outage of uncertain duration most disruptive for your company, Daytime or Nighttime?

    A. Day time B. Night time C. Both equally disruptive D. None E. All equally disruptive F. None

21. When is an unplanned outage of uncertain duration most disruptive for your company, Week days or weekends?

    A. Week days B. week night C. Both equally disruptive D. None E. All equally disruptive F. None

22. If the utility company gives a prior information about the power outages it will reduce the loss which will be incurred due to a sudden outage by a significant amount.

    A. Strongly agree B. Agree C. Neither agree nor disagree (Neutral)

    D. Disagree E. Strongly disagree

23. How much does your company currently pay every month for electricity received from the electricity company ....?

24. Is there any difference in costs paid for months with longer hours of outage?

    A. No B. Yes

25. Has your company ever suffered damage of appliances or equipment's resulting from abnormal power release?

    A. No B. Yes

26. If your answer is yes for the above question what is the estimated cost of the damage in birr? ________________________

PART 3: WILLINGNESS TO PAY (WTP) FOR IMPROVED ELECTRICITY SERVICES

Now you will be asked some questions regarding your companies' willingness to pay to avoid power outages. The following characteristics and the levels each characteristic may take will define your electricity service:

1. Frequency of outages: This refers to the average number of outages per month. You will be presented with three frequencies: twice a month, 5 times a month and seven times a month.

2. Duration of outages: This shows how long on average an outage lasts. You will be presented with three durations: one hour, two hours and three hours.

3. Type of outages: This is the type of outage. You will be presented with two types of outages: outages with prior information and outages without prior information. With prior information refers to the type of outage which the electric power provider gives the information to the customer that there will be a power cut at a specific date and time. To the contrary outage without prior information refers to a sudden power cut without prior information given to the customer.

In order to provide improved electricity services, the Government (Service provider) has to make major capital investments and cover maintenance costs of the new project. The level of investment and maintenance costs required to provide a service depends on the levels chosen for each of the attributes defined above. The Government will pay for this investment and maintenance costs by collecting money from the electricity users. For example, reducing the number of outages requires higher investment and maintenance costs and as a result, the tariff charged to the users will be higher.

You will be given with 6 choice-sets one by one. In each choice set, you will be presented with two electricity service alternatives. For each alternative, we will state the frequency, duration, time and Duration of power outages. These characteristics are identical throughout the choice sets. However, their levels will be changed.

For each set, I want you to state which alternative you think is best for your company. Note that your choice will not affect anything other than the frequency of power outages, the duration of outages, the type of outages and the additional cost on monthly electricity bill, everything else remains as it is today

Q.1 Assuming That the Following Two Services and Your Current Service Were the Only Choices You Have, Which One Would You, Prefer put a thick mark on the [ ] at the bottom of the option of your choice

CHOICE SET 1

	Option A	**Option B**	**Current Service**
Frequency of outages	Three times a month	Outage twice a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	Outages for two hours	Outage for three hours	
Type of outage	With prior information	Without prior information	
Additional cost on monthly electricity bill	2.5% of average monthly bill	5% of average monthly bill	
	[ ]	[ ]	[ ]

CHOICE SET 2

	Option A	Option B	Current Service
Frequency of outages	five times a month	Three times a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	Outages for one hour	Outage for two hours	
Type of outage	With prior information	With prior information	
The additional cost on monthly electricity bill	2.5% of average monthly bill	2.5% of average monthly bill	
	[ ]	[ ]	[ ]

CHOICE SET 3

	Option A	Option B	Current Service
Frequency of outages	Outage once a month	Five times a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	Outages for three hours	Outage for one hour	
Type of outage	Without prior information	With prior information	
The additional cost on monthly electricity bill	5% of average monthly bill	2.5% of average monthly bill	
	[ ]	[ ]	[ ]

CHOICE SET 4

	Option A	Option B	Current Service
Frequency of outages	Outage once a month	Three times a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	Outages for two hours	Outage for one hour	
Type of outage	With prior information	With prior information	
The additional cost on monthly electricity bill	7.5% of average monthly bill	5% of average monthly bill	
	[ ]	[ ]	[ ]

CHOICE SET 5

	Option A	**Option B**	**Current Service**
Frequency of outages	Three times a month	Five times a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	Outages for three hours	Outage for two hours	
Type of outage	With prior information	Without prior information	
The additional cost on monthly electricity bill	2.5% of average monthly bill	1.5% of average monthly bill	
	[ ]	[ ]	[ ]

CHOICE SET 6

	Option A	**Option B**	**Current Service**
Frequency of outages	Five times a month	Once a month	Neither Service A nor Service B: I prefer to stay with my current service
Duration of outages	Outages for one hour	Outage for three hours	
Type of outage	With prior information	Without prior information	
The additional cost on monthly electricity bill	2.5% of average monthly bill	5% of average monthly bill	
	[ ]	[ ]	[ ]

SECTION 4: FOLLOWUP QUESTIONARY FOR THOSE WHO CHOOSE THE CURRENT SERVICE

Q1. If you responded that you choose the current service to all choice set presented for you. You choose that option because …

1. You are happy with the current service; the current service is good; the current service is not too bad.
2. The alternatives in the choice sets are not any different from the current service.
3. Afraid the prices will increase more.
4. The current service is financially better.
5. Others
6. No specific reason