Addis Ababa University

Addis Ababa Institute of Technology

School of Mechanical and Industrial Engineering

ASSESSMENT OF SERVICE QUALITY IMPROVEMENT ALTERNATIVE DECISION.

(A Case Study at Ethiopian Electric Utility (EEU))

By: Endale Alemayehu

Dr. Ameha Mulugeta (Advisor)

June, 15/2018

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Declaration:

I hereby declare that the work which is being presented in this thesis entitled "ASSESSMENT OF SERVICE QUALITY IMPROVEMENT ALTERNATIVE DECISION" is original work of my own, has not been presented for a degree in any other university and all resources used in the thesis have been duly acknowledged.

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ACKNOWLEDGMENT

First of all, I would like to thank the Almighty God for His provision of Grace to overcome trials and temptation to complete the entire work. Then all my family thanks for supporting and understanding me, especially my wife and mother.

Secondly, I would like to express my utmost gratitude to my advisor Dr. Ameha Mulugeta and co-advisor Ato Asefaw Regassa for their expert guidance, constructive comments, suggestions and encouragement without which this work could have not been completed. I am grateful to their motivation for the timely completion of the research, and their dynamic suggestions for solutions to any challenges during the total work of this thesis.

I would like to extend my deepest appreciation to, all staff members of EEU, MOWIE, EEA, and Ato Girma Lemma, W/ro Yemisirach Belay, for their support by giving me the information that I need and encouragements. Thank you all very much.

Finally to my friends and sigma electric staffs who are there whenever I need them to support me in my work.

Endale Alemayehu

June, 15/2018

ABSTRACT

Service quality is the ability of the organization to meet or exceed customer expectations. It is the difference between customer expectations of service and perceived service. If the service provider meets or exceeds customer expectation then customer satisfaction occurs. To insure the customer satisfaction, customer service plays vital role. Customer service is the interaction between the customer and service provider. Quality customer service entails providing efficient, quick and friendly service, handling complaints quickly and responding to customers' issues on time. EEU failed to meet its customer expectation, especially in its technical service (operation & maintenance) mainly unplanned service outage, new power connection and customer service. Leaving aside power shortage, technological and financial constraints dissatisfaction occurred due to lack of accountability & responsibility, poor monitoring & controlling mechanism, high bureaucracy, no transparency, and lack of motivation from its employees.

EEU has outsourced (contracted out) it bill collection to private sector (Kifeya Lehulu) since two years back. Bill collection service have got a moderate satisfaction level from previous poor satisfaction level. This study shows EEU's technical service (operation and maintenance) quality of service delivery can be enhanced by outsourcing this scope to the private sector. MCDM AHP & TOPSIS tools used to analyses sector expert's judgements or opinion (primary and secondary data) & case observation were used to ensure the current service quality. From sector performance indicators (KPI), kept four criteria which are customer service, unplanned outages, safety & employees commitments. Weights of this criteria's using AHP tools for better service delivery at EEU found unplanned service outages (34.63%), customer service (27.48%), employees commitments (20.64%) & safety (17.24) Result of preference from in-house and outsourcing service delivery by AHP & TOPSIS analysis gives 70% & 86.67% respectively, which indicates that EEU's technical service (operational & maintenance), service quality level can be enhanced compared from current EEU's current in-house operation. Finally recommendation is forwarded to deliver standard electricity utility service by contracting out the operation & maintenance in order to place EEU in competitive environment and effectiveness.

Key words: - Service quality, customer service & satisfaction, outsourcing, AHP, TOPSIS

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LIST OF ABBREVIATIONS

EEU: -	Ethiopian Electric Utility
EEP: -	Ethiopian Electric Power
EEA: -	Ethiopian Electric Authority
MOWIE: -	Ministry of Water, Irrigation and Energy
SAIDI: -	System average interruption duration frequency index
SAIFI: -	System average interruption frequency index
AHP: -	Analytic Hierarchy Process
SAW: -	Simple Additive Weighted
TOPSIS: -	Technique for Order Preference by Similarity to Ideal Solution
ELECTRE: -	Elimination and Choice Translating Reality (English)
PROMETHEE: -	Preference Ranking Organization Method for Enrichment Evaluation
RUV: -	Relative utility value
SSNP: -	Social Safety Net Program
PPP: -	Public-Private Partnerships

CHAPTER ONE
1. Background and Introduction

1.1 Introduction

Energy is the lifeblood of the global economy a crucial input to nearly all of the goods and services of the modern world. Stable, reasonably priced energy supplies are central to maintaining and improving the living standards of billions of people. Energy is a crucial ingredient for economic development. As both agricultural and industrial activities increase, the demand for energy similarly increases. In the developing world provision of a greater access to energy has been suggested by some that will help grow their economies and improve the lives of the poor.

The Ethiopia Government places universal electrification at the core of its 2025 poverty reduction and development agenda, embedded in the ongoing Growth and Transformation Plan (GTP) II. Adequate, affordable, and reliable access to electricity is instrumental to the structural transformation of Ethiopia's economy and society, including massive poverty reduction and a shift towards higher productivity rates and industrialization. Without electricity, Ethiopia cannot develop a domestic manufacturing capacity adequate for local needs and exports, industrial parks, private sector entrepreneurship, the ICT and financial sectors- nor graduate to a middle-income country. (Ministry of Water, May 29, 2017)

Currently, Ethiopia is following an agricultural lead industrialization strategy, and is achieving encouraging results. The economy has been growing at a rate of more than 10 percent for the last six years consecutively and a large number of development projects are underway. The National energy policy of the country emphasizes the need for equitable development of the energy sector in parallel with other social and economic developments. (Berhanu, October, 2015)

The country is well endowed with hydro power potential. According to the current estimates, this potential goes beyond 45,000 MW. Currently the power sector is operated by the Ethiopian Electric Power (EEP) responsible for the generation & transmission, & Ethiopian Electric utility (EEU) which is responsible for distribution and sales of electricity (retailing of the electricity service) nationwide. (Ministry of water, 2018) ((EEU), 2018)

Table 1.1 Energy sector related GTP-II Targets

Indicator	***Unit of measurement***	***Baseline (2015)***	***GTP-II targets (by 2020)***
Electricity service coverage (owns/villages)	Percent	60	90
Installed power generating capacity	MW	4,180	17,347
Length of power transmission line	KM	16,018	21,728
Number of customers connected to grid power	Number	2,310,000	6,955,000
Annual per capital electricity consumption	KWh	86	1,269
Improved cook stoves and biogas plants	Number	8.9 million stoves and 11,618 biogas plants	11.45 million (including 31,400 improved biogas, 20,000 households biofuel stoves)
Solar lanterns	Number	2 million	3.6 million
Household solar systems	Number	40,000	400,000

Source: (Utility, 2016)

To give better service the Ethiopian government unbundled the former Ethiopian Electric Corporation (EEPCO) into two separate entities that is Ethiopian Electric Power (EEP) and Ethiopian Electric Utility (EEU) through Council of Ministers Regulation No. 302/2013 and NO. 303/2013, respectively, enacted on December 27, 2013.

The Ethiopian Electric Utility (EEU) was established as public utility enterprise for indefinite duration, and conferred with the powers and duties of the previous Ethiopian Electric Utility. The purpose of the organization is mainly to engage in the business of distributing and selling electrical energy in accordance with economic and social development policies and priorities of the government and to carry out any other related activities that would enable it achieve its purpose. (Wedajo, May, 2015)

Main function of the organization is summarized below:-

1. To construct and maintain electric distribution networks; to contract out the distribution networks construction to contractors as required;
2. To administer electric distribution networks, to purchase bulk electric power and sell electric energy to customers by new power connection & recover service outage/Interruption.
3. Bill collection from its customer, to initiate electric tariff amendments and, upon approval, to implement same;
4. In line with directives and policy guidelines issued by the Ministry of Finance and Economic development, to sell and pledge bonds and to negotiate and sign loan agreements with local and international financial sources;
5. To undertake any other related activities necessary for the attainment of its purposes. ((EEU), 2018)

To get new management capacity and to improve the customer service delivery the government provides the management of Ethiopian Electric Utility to foreign company (A consortium of three Indian companies under the management of power grid corporation of India-PGCI-which is responsible for operations, distribution, and sales services). The company won the contract for 21 million USD and start working at 2014, and terminated at 2015 even though not visible changes for service delivery, as per EEU's employees comment.

The electricity delivered to your home or business is typically generated in large centralized power plants, Power then travels over long distances via high voltage transmission lines, which are interconnected in a grid or network configuration .From the transmission system, power travel to distribution substations. From these substations, distribution lines, operating at lower voltage levels, disperse the power throughout cities and neighborhoods. For safety reasons, each distribution lines are protected by circuit breaker in the substation. The power then travels from the distribution line through a service transformer located in close proximity to your home or business. Electricity enters the facility either through over head or underground service entrance conductors (wires) which connect to the meter. EEU reads this meter on a monthly basis and reports the information gathered to the billing department and the respective department sold the bill. (Berhanu, October, 2015)

Customer service is one of the most important tools that help an organization to achieve a high level of profitability and long term success. It is important to note that EEU must continually improve its services because people's expectations and needs keep on changing. However, EEU has been subject to a lot of criticism from the public in the quality of services it provides to them. Hence an important analysis was made about the customer expectations and perceptions regarding to the services that EEU are provides. (Wedajo, May, 2015)

Starting from 2015 EEU launched a customer service through telephone line number 905, deploying about 50 operators for replying to customer demand and transfer the request to the urgent technical maintenance team, through simple transfer of the messages, however there is no time registration performance measurement and feedback mechanism between the operators and the maintenance team or customers, with regard to completion of the service requested.

One important aspect of EEU operations is its dealing with customers in order to achieve their satisfaction through determining their needs and establishing the operation system that deliver such needs. Quality in a service organization is a measure of the extent to which a delivered service meets the customer's expectations. It is determined by the customer's perception and not by the perceptions of the providers of the service. It is therefore, very important to determines customer needs and wants and, then design the service process to meet these requirements. (Wedajo, May, 2015) (Berry, Zeithaml, & Parasuraman, 1990)

1.2 Statement of the Problem

Different past studies on service quality and customer satisfaction survey by (Berhanu, October, 2015) (Israel Behanu 2016, (Wedajo, May, 2015) Daniel Wedajo 2015, Zerithu Fiker 2014 & Seyoum Akele 2013) shows that company/(EEU) fails to meet customer expectation. There is very high dissatisfaction in EEU's service like, very low responsiveness (poor customer service), time delay for new connection, poor complaint handling and recovery time for unplanned outages/interruption. EEU has failed basically to provide a reliable service to its customers. (Berhanu, October, 2015) Assessment of service delivery quality and customer satisfaction study in Ethiopian Electric Utility are below the expectation of customers. (Wedajo, May, 2015)

Past studies show that regarding the level of customer satisfactions on electricity tariff prices and billing collection methods services are found moderate. EEU technical services which are customer service or complaint handling, service outage/interruption recovery and timely new power connection

to customers generally as well as its operation & maintenance are poorly satisfied. (Berhanu, October, 2015) (Wedajo, May, 2015)

The past studies identified the following factors or causes for the dissatisfactions.

1. High electricity demand
2. Electricity distribution system lacks technological advancement
3. Lack predetermined service standard, poor monitoring & controlling mechanism
4. Poor customer service, not having transparent complaint handling system
5. Very poor technical service (operation & maintenance) like, long time for unplanned service outage recovery and delay in new connection
6. High resource shortage and unbalanced deployment
7. Lack of motivated, skilled and well-disciplined human resource (Berhanu, October, 2015) (Wedajo, May, 2015)

Service outsourcing is one way of improving service quality especially for government (public) service. (Tallaprugada, June 2009) From EEU's experience for the billing collection service quality improvements, which was found by outsourcing to the private sector (Kifiya Lehulu). From the researcher observation, which is confirmed also by company/ (EEU), still there is no change of technical service delivery methodology for improvement of service quality.

This study attempts to assess the preference for quality service delivery between EEU's in-house operation (current service delivery) and outsourced (contract out) the same operation to private sector at technical service of EEU.

1.3 Research Questions

1. What will be the preference for better quality service delivery between EEU's in house & outsourced technical service delivery?
2. Can the technical service quality of EEU be enhanced or improved by outsourcing?
3. What type of decision approaches could be used in outsourcing EEU service for enhanced customer service?

1.4 The Objectives of the Research

The general objective of this study is to determine the preference (selection) for better quality service delivery at EEU, in scope of technical service delivery between in-house services (current service delivery by EEU) or outsourced service delivery (contracted out).

1.4.1 Specific objectives

To address the general objective of the study, the following specific objective will be studied:-

- To analyze and determine the significance improvement level by comparing in-house service with outsourced service by criteria, customer service (responsiveness), unplanned service outages (reliability), safety & employee's commitment.

1.5 Limitations and the Scope of the Study

1.5.1 Scope of the study

The scope of this project is focused on service quality improvement at EEU's technical service delivery, leaving aside power shortage, technological and financial constraints on the company (as the current company infrastructure situation) that to assess the greater service quality delivery scheme in comparing EEU's in-house service (current service) & outsourced service. In more specific terms the study emphasis on a greater EEU's technical service quality preference from in-house or outsourced service delivery, in consideration of current situation & infrastructure.

1.5.2 Limitations of the Study

The researcher faced lack of sufficient data to investigate more facts and information in conducting this research. Especially, to show the two alternatives with cost benefit analysis, the researcher could not get any financial data from the company. Due to this the researcher was unable to perform cost benefit analysis for strengthening the results of the analysis. From many decision making tools this study used only two methods, which is AHP (analytical hierarchical process) & TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), these methods are more suitable for intuitive and clear logic that represent the rationale of human choice (expert choice).

1.6 Significance of the Study

The significance of this study is to investigate the relationship between outsourcing and operational performance of EEU towards service quality improvement, specifically the study sought to determine the relationship between the key outsourced services, that technical service outsourcing and current operational performance towards customer requirements and making decision using multi-criteria decision making methods, AHP & TOPSIS. The electricity utility concerned stakeholders and the management of EEU would be able to evaluate the outsourcing/contracting services strategy and decide whether it is working in line with company's goals and objectives.

1.7. Organization of the Documentation

This research paper is organized into six chapters. The first chapter deals with research preliminaries including background, statement of the problem, objectives, scope of study and outline of the paper. Chapter two which focus on reviewing literatures that are related with the issued considered under the research project. Chapter three describes research design and methodology and it includes the research design, data type and source, method of data collection, method of data analysis and ethical consideration. Chapter four is overview of the sector and public service quality. In Chapter five, the gathered data are statistically analyzed using AHP & TOPSIS decision making methods. The last chapter that is chapter six includes summary of findings, conclusion and recommendation. In addition to the above chapters, list of reference materials and appendices for questioners, used templates sheets & summary of literature review.

CHAPTER TWO
2. Related Literature Review

2.1 Introduction

In this chapter, pertinent topics are discussed in line with the study area to get basic theoretical information and knowledge to strengthen the research output. The literature review focused on; general service quality, public sector service quality, electricity utility service quality, customer satisfaction and service quality, quality improvement by outsourcing to private sector and previous related studies for service quality improvement in electricity utility service.

2.2. Service Quality concept and models

The definition of quality may vary from person to person and from situation to situation. The definitions of service quality vary only in wording but typically involve determining whether perceived service delivery meets, exceeds or fails to meet customer expectations. (Agyapong, November 9, 2010)

According Parasuraman etl 1985, defines service quality as an overall judgment similar to attitude towards the service and generally accepted as an antecedent of overall customer satisfaction. Parasuraman etl 1985 continued that, defined service quality as the ability of the organization to meet or exceed customer expectations. It is the difference between customer expectations of service and perceived service. Perceived service quality results from comparisons by customers of expectations with their perceptions of service delivered by the suppliers. If expectations are greater than performance, then perceived quality is less than satisfactory and hence customer dissatisfaction occurs. (P.R. Munhurrun, 2010) (A.Parasuraman, Oct,2010)

Quality is a measure of how closely a product confirms to customers' needs, wants and expectation. It is a degree to which a product conforms to customer expectation and specification. Customers service quality expectation is formed by their past experience, word of mouth, service firm advertising and personnel needs. They compare the perceived service with expected service. If the perceived service fall below the expected service customers lose interest in the provider and if the perceived service meets or exceeds the expectation they are select to use the provider again. Service quality is a focused evaluation that reflects the customer's perception of elements of service such as Interaction quality, physical environment quality and outcome quality. These elements are in turn Evaluated based on specific quality dimensions. (Wedajo, May, 2015) (A.Parasuraman, Oct,2010)

2.3 Service Quality Models

During the past few decades, service quality has become a major area of attention to practitioners, managers and researchers owing to its strong impact on business performance, lower costs; customer loyalty and profitability. There are different service quality models. They include : technical and functional; quality model, gap model, attribute service quality model, synthesized model of service quality, performance only- model, ideal value model, evaluated performance quality model, etc. All the models have different implications and quality improvement aspects. But in many application areas, the conceptual model of service quality or the gap model is commonly accepted by many researchers and used in practical application. (A.Parasuraman, Oct,2010)

As stated above, Parasuraman etl 1985, defined service quality as the difference between perceptions and expectations, also known as Gaps model or conceptual service quality model. The wider the gap, the more is the need to improve service quality by the service provider.
The conceptual service quality model or Gaps Model of Service Quality reflects that perspective and offers service organizations a framework to identify services in the form of the gaps that exceed (or fail to meet) customers' expectations. (Shahin)

The model posits seven gaps that reflect a discrepancy between: as shown in below fig.2.1

- Gap1: Customers' expectations versus management perceptions: as a result of the lack of a marketing research orientation, inadequate upward communication and too many layers of management.
- Gap2: Management perceptions versus service specifications: as a result of inadequate commitment to service quality, a perception of unfeasibility, inadequate task standardization and an absence of goal setting.
- Gap3: Service specifications versus service delivery: as a result of role ambiguity and conflict, poor employee-job fit and poor technology-job fit, inappropriate supervisory control systems, lack of perceived control and lack of teamwork.
- Gap4: Service delivery versus external communication: as a result of inadequate horizontal communications and propensity to over-promise.
- Gap5: The discrepancy between customer expectations and their perceptions of the service delivered: as a result of the influences exerted from the customer side and the shortfalls (gaps) on the part of the service provider. In this case, customer expectations are influenced by the extent of personal needs, word of mouth recommendation and past service experiences.

- Gap6: The discrepancy between customer expectations and employees' perceptions: as a result of the differences in the understanding of customer expectations by front-line service providers.
- Gap7: The discrepancy between employee's perceptions and management perceptions: as a result of the differences in the understanding of customer expectations between managers and service providers.

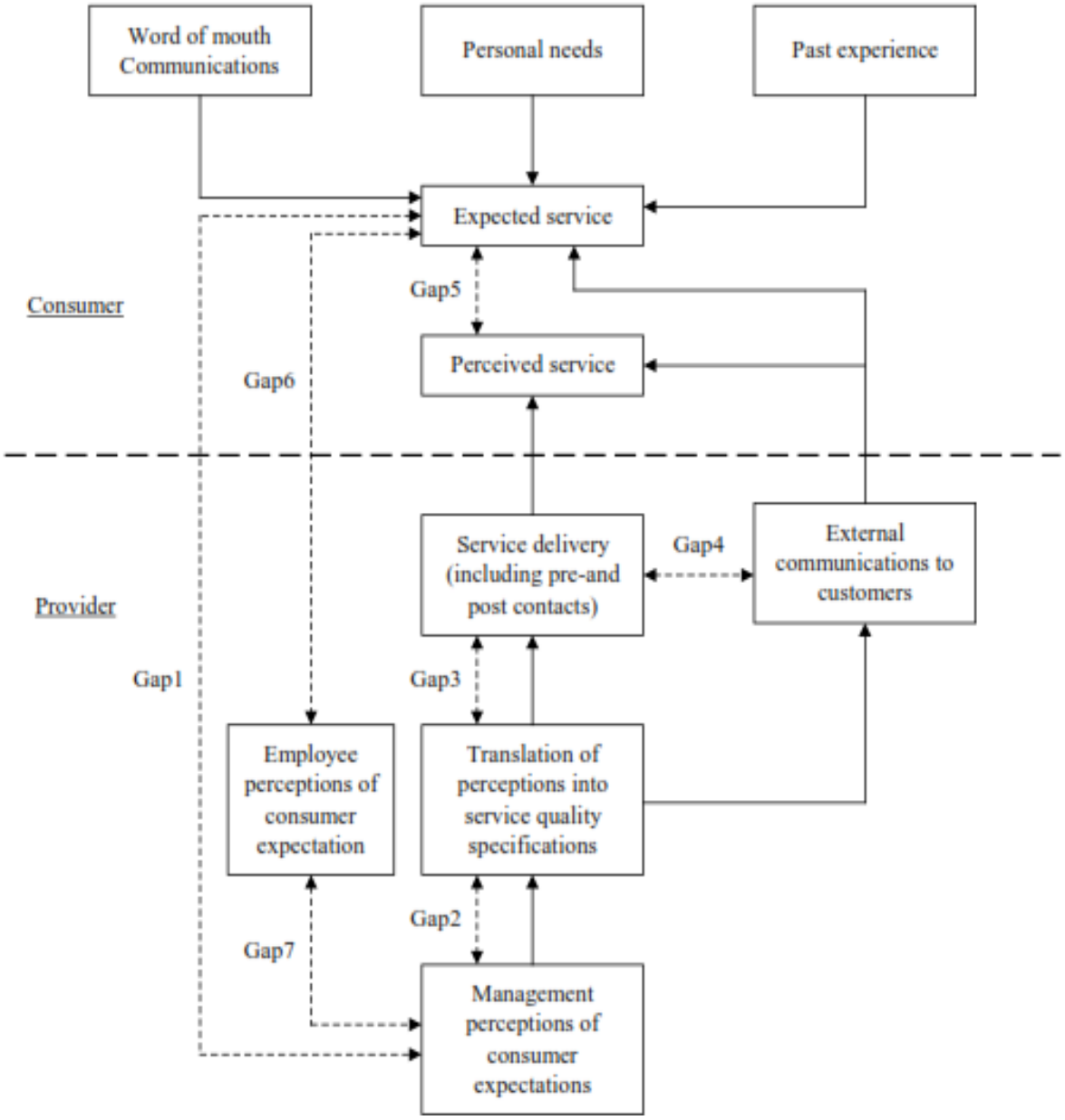


Figure 2.1 Conceptual model of service quality
Source: (Shahin) (Parasuraman, et al., 1985; Curry, 1999; Luk and Layton, 2002)

According to Dr. Arash Shahin "the gap model is one of the best received and most heuristically valuable contributions to the services literature". The model identifies seven key discrepancies or gaps relating to managerial perceptions of service quality, and tasks associated with service delivery to customers. The first six gaps (Gap 1, Gap 2, Gap 3, Gap 4, Gap 6 and Gap 7) are identified as functions of the way in which service is delivered, whereas Gap 5 pertains to the customer and as such is considered to be the true measure of service quality. The Gap on which the SERVQUAL methodology has influence is Gap 5. (Shahin)

SERVQUAL as the most often used approach for measuring service quality has been to compare customers' expectations before a service encounter and their perceptions of the actual service delivered. (A.Parasuraman, Oct,2010) The SERVQUAL instrument has been the predominant method used to measure consumers' perceptions of service quality. It has five generic dimensions or factors and are stated as follows:-

1. **Tangibles** involve the appearance of physical facilities, including the equipment, personnel, and communication materials.
2. **Reliability** involves the ability to perform the promised service dependably and accurately.
3. **Responsiveness** involves the willingness to help customers.
4. **Assurance** involves the knowledge and courtesy of employees and their ability to convey trust and confidence. This assurance includes competence, courtesy, credibility and security.
5. **Empathy** involves the provision of caring, individualized attention to customers. This empathy includes access, communication, and understanding the customer. (A.Parasuraman, Oct,2010), (Agyapong, November 9, 2010) (Shahin) & (Berry, Zeithaml, & Parasuraman, 1990)

2.4 Service Quality in the Public Service

Service provision is more complex in the public sector because it is not simply a matter of meeting expressed needs, but of finding out unexpressed needs, setting priorities, allocating resources and publicly justifying and accounting for what has been done. In addition, it should pointed out that public sector employees are currently confronted with new professional challenges arising from the introduction of new principles and tools inspired by the shift to new public management. (P.R. Munhurrun, 2010)

Customer-oriented service mindset was the top task of public sectors or organizations and all members shall focus on customers. When going to public sector for public affairs, people often had to visit various departments, repeating filling out the similar forms; or going to and fro departments with documents in the section system with unclear responsibility division. With "customer-oriented" service mindset, customer value could be the important basis of administration, directly interact with customer (people), collect customer related information, and thereby improve service and product. (J.S.Lin, 2010)

In related literatures about government service quality, government institution service quality was mostly discussed in aspect of demand or strategy. Service quality study was normally done in PZB model proposed by Parasuraman, Zeithaml, and Berry. (A.Parasuraman, Oct,2010) PZB drives hot tide of service quality study.

Later, in 1988, SERVQUAL service quality scale was introduced, making service quality the most-striking hot spot of research. While public sector varied in characteristic due to variable systems, national institutions and administrative institution varied each other. Customer demand was initially studied, service quality definition depended on initial result, extending all way to customer expectation of service provided. (J.S.Lin, 2010) Customer-oriented result was usually evaluated on subjective identification of external customer, customer was the sole judge of service quality, if evaluating result only, and then customer-oriented service did not penetrate internal institution. If discrepancy occurred between administrative institution business and customer object, then satisfaction evaluation result was often doubted of impartiality and professionalism.

Type of organization	Sub-category	Reasons for emergence	Strength	Weakness	Conditions for success
- Public	- Public	- Historically determined - Strong public institutes (sufficient tax revenue, etc) - Monopolistic tendency of network water supply - Water supply extremities	- Protects customers against exploitations - Can ensure equitable distribution of services - Could give consumers a voice	- Lack of access to capital - Lack of political will charge cost recovering tariffs - Lack of institutional capacity - Inefficient operations - Exposed to cross-subsidization to other government services	- Strong political legitimacy for government - Government charge cost recovering tariff (no history of subsidizations) - Long term view taken by government - Public sector reform to improve efficiency - Access to sufficient capital
- Private FP	- Fully private	- Unmet need - Areas that are costly to provide with network water - Entrepreneurial private sector - Environment not attractive for large companies	- Provides access to unserved areas - High level of competition	- More expensive than network water - Environmental concerns - Price fixing could occur	- Unfeasibility of central network - Regulating of private providers (to avoid price fixing and ensure quality standards)
	- PPP	- Luck of public capital technical capacity - Weaknesses of public supply (low tariff levels, poor maintenance)	- Increase competition (during tendering stage) - Provides inflow of private capital - Introduces private sector knowledge, technology and capacity	- Private monopoly (erodes public power) - Inequitable supply - Lack of transparency with regulator - Consumers have little voice	- Political legitimacy - Stable institutional Environment (legal, political etc.) - Strong regulatory control by public sector (Equity, tariff level, environmental and quality standards etc.) - Full information discloser to public regulator
- Non-Profit	- SSNP	- Unmet need - Strong communal action - User group equality	- Responds to unmet need - Significant user participation - Increase distribution equity	- Lack technical capacity - Lack access to capital - Could be “captured” by political groups	- Strong communal participation - Relative equality in the user group
	- Large NP	- Failure of PPP’s exploitation of users by overcharging - Public support for non-Profit ownership (over for profit)	- Non-distributive constraint protects users form exploitation (increased legacy) - Representation for users (membership) - Able to pay market salaries	- Managerial inefficiencies (due to incentive problems) - Difficult to access capital - Possible “capture” by certain user groups	- Political legitimacy - Legal framework that allows non-profits - Public sector regulator

Table 2.1 Different organization categories with their weakness & strength on the service delivery.

Source: - (R.Ashworth)

2.5 Service quality in the Private sector

Within the market oriented private sector, the relationship between service provider and customer is normally direct and comparatively straightforward. If the service on offer to the customer meets an actual or perceived need, at a competitive price, it will normally be demanded and sold. In such conditions, customer satisfaction should find expression through the level of sales as supply seeks to meet that demand. (Humphreys, 1998)

Private sector service providers are not bound by government procedures and practices. They may have more flexible, innovative and effective ways of delivering services and ensuring the services reach the people they are meant for. Examples of this might include offering longer or more flexible service hours built around end users' requirements and providing access to services via technology. (Outsourcing, Serving the Community By Using the Private Sector A General Guide to) (Ong, 2 July 2014)

2.6 service quality improvement strategies

To survive and competent on the market service provider should be under continues quality improvement process to meet customer expectation. There are different approaches to handle the dynamism of market, customer needs, profitability and competitive.

Examining the service literature reveals this choice reflected in four primary themes.

Table 2.2: Quality Improvement approaches

S.no	Quality improvement approaches	Short description
1	Culture-based Improvement	• Based on the soft side of the total quality management movement. • providers' ability and willingness to be flexible according to customers' needs, due to management style, organization structure, incentive system etc.
2	Design-based Improvement	• Improvement by addressing quality through design. • Using design in this manner linking the design to customer needs, linking the design to customer perceptions, and direct psychological manipulation of satisfaction through design.
3	Variation-based Improvement	• approach taken is variance reduction through parameter design developed by Taguchi • involves adjusting the parameters of the design so that the variation of the inputs produces a minimal variation in the outputs
4	Failure-based Improvement	• Viewing each defection as a failure of the service system, and promotes the use of failure analysis to drive changes to the system, which are assessed by changes in the cost of defections.

Source: (M.Stewart) (P.R. Munhurrun, 2010)

From the above discussion and many related literature showed that service quality improvement is different from sector to sector and public to private. In most of previous studies service quality improvement was fall under culture-based improvement, which is focused on individual and group (management) psychology. (M.Stewart)

2.7 Improvement of public service quality and the role of private sector

2.7.1 Improvement of public service quality

The resulting focus on service quality improvement has forced public service managers to engage with the measurement of service quality. They have had to become involved increasingly in assessing satisfaction of both external and internal customers service users as well as deliverers of services. (SAUNDERS) There are three different sets of influences on performance, distinguishing between those which are external to the organization and which therefore form its environment, those which are intrinsic to it like its structure, culture, processes, and leadership and those which are adopted by it in the form of strategies that might improve performance. (R.Ashworth)

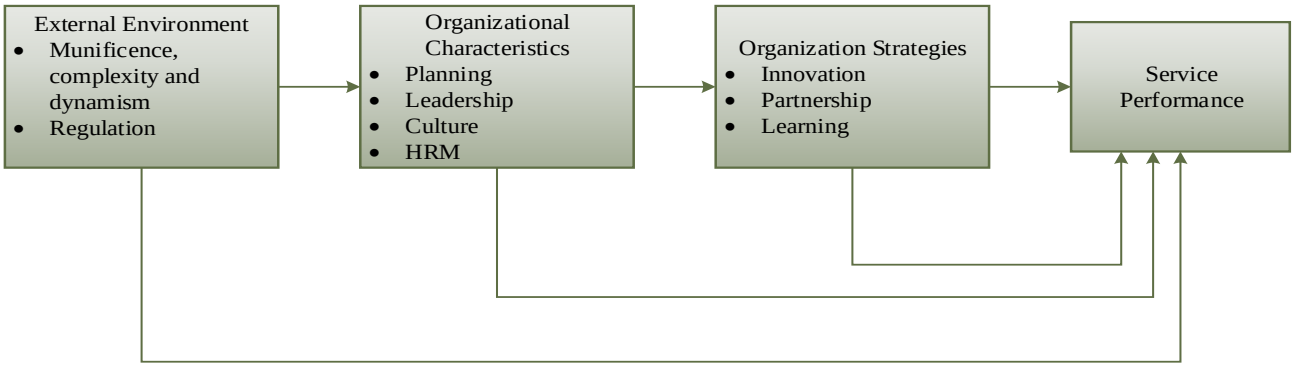


Fig. 2.2 Service performance improvement
Source: - (R.Ashworth)

Public sector reform movements around the world in the 1990s, codified as New Public Management (NPM) have been aimed at 'fostering a performance-oriented culture in a less centralized public sector'. Such reforms are characterized by key elements including increasing use of markets and competition in the provision of public services (e.g., contracting out and other market-type mechanisms) and increasing emphasis on performance, outputs and customer orientation. One consequence of these reforms has been the reorientation of public services towards their consumers.

(SAUNDERS) This has brought with it pressure for better quality public services, from service users as their needs change and their expectations rise in respect of how well services can be performed.

Some other author's classified improvement actions into two different categories. At the one hand actions are targeted at remediating dissatisfaction with procedural or process related issues. Organizations are working on simplifying, designing or redesigning processes. Work out different or better ways in delivering the service(s). At the other hand improvement actions are focusing on elements relating to personal aspects of the delivering of services. Actions in this context relate to training and behavioral aspects of staff. (Nick, 2011)

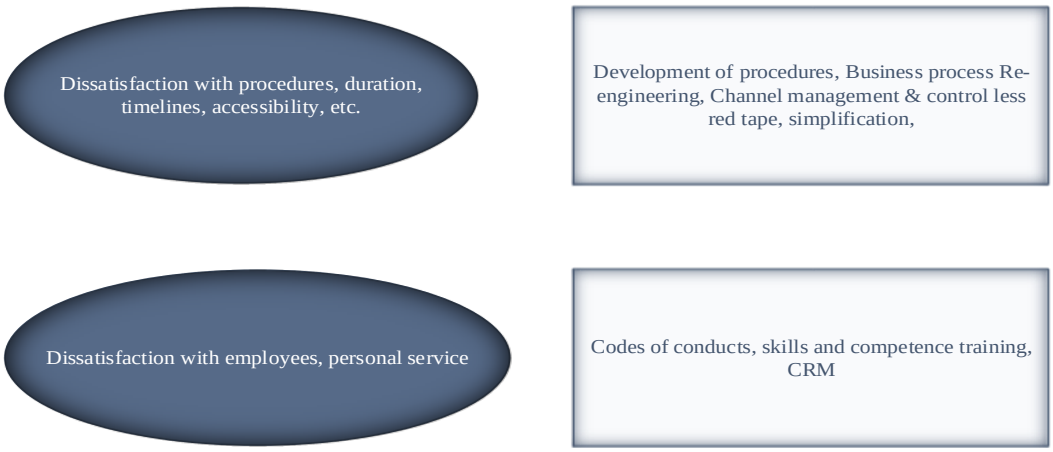


Fig. 2.3: - Classification of improvement action

Source: - (Nick, 2011)

2.7.2 Private sector participation (PSP) for public service quality improvement

Private Sector Participation (PSP) has been increasingly used for infrastructure development all over the world. However, the studies that have been conducted to determine the impact of PSP on project outcomes has indicated mixed results. However, when accompanied by appropriate regulatory and competition reform, it can have positive impacts on these outcomes. Without support from government, PSP can have negative impacts on the infrastructure access of poor and rural populations. (T.R Annamalia, 2013)

Most literature debated on PSP service quality improvement, some of them said that it depends on the nature of the sector and many reason for improvement of service delivery by private sector. Some others result shows there will not be significant change on the service quality by PSP. (K.Gassner)

We consider five types of PSP in our analysis – concessions, divestitures, leases, management contracts and service contracts. Each of these types is described in the following section. (T.R Annamalia, 2013)

2.7.3 Forms of PSP included in the review

Various forms of PSP can be seen in the development and operation of infrastructure facilities. For the purpose of this study, the following forms of PSP will be considered:

A. **Divestitures:** In this form of PSP, the government sells an existing state owned enterprise through a stock offering to the general public or sales it to private investors in 100% and indefinite time.
B. **Service contract:** In this form of PSP, the public sector signs multiple contracts with the private sector for procuring a variety of services (such as billing and collection services).
C. **Management contract:** This is a form of PSP in which the private sector is responsible only for management and not investment.
D. **Leasing:** In this model, the public sector assumes responsibility for investment and financing the asset, whereas the private lessee is responsible for maintenance and operation of the facilities to provide services.
E. **Concession contract:** The government offers a contract to the private investor to invest and operate an infrastructure project or asset during the concession period. Such concessions are broadly called Public-private Partnerships (PPP), because in many instances the public sector is also a joint venture partner in the project company that is implementing the project. (T.R Annamalia, 2013) (K.Gassner)

Especially in public service the improvement strategy will be initiated by reform due to pressure from citizen or customer service satisfaction. Most of this reforms implemented and achieved remarkable service quality improvement through private participation in the sector, incentives schemes, and creating competition in the sector.

From the above points (in section 2.6), it was clearly mentioned that service quality improvement by culture-based improvement will focus on the individual and group psychology with respect to service quality, meaning the employees and management commitment towards quality. Especially on public service quality improvement culture based improvement and reform improvement (private participation, incentive schemes and competition) will indicates that contract out its service (outsource) will cover two of the above point of view for better service delivery.

2.8 Outsourcing

Outsourcing is simply acquiring a product or service form outside supplier rather than producing in the organization or it is transfer or delegation of the operation and day-to-day management of the business process to an external service. Presently many organizations outsources one or more of the business function from outside vendors. Moreover, as various researches indicate the trend of outsourcing throughout the world has been increasing from time to time. (Mulat, July 2007)

Outsourcing is the contracting out of a business process to a third-party, transferring employees and assets from one firm to another or the practice of handing over control of public services to for-profit corporations. Outsourcing includes both foreign and domestic contracting and sometimes includes off-shoring or relocating a business function to another country. Outsourcing can offer greater budget flexibility and control and allows organizations to pay for only the services they need, when they need them. (O.Makowenga, October, 2013)

2.8.1 Discussion of Pros & Cons of the outsourcing

The general argument is that outsourcing and opening public sectors like health care and education to competition boost economic efficiency and output. There is a concern, however, that outsourcing could lower service quality. A survey of the literature concludes that the effects of public-sector outsourcing on service quality depend on the type of service outsourced. (K.Gassner)
Outsourcing generally reduces costs without hurting quality for services that are easy to standardize, like garbage collection. The same appears to hold, for the most part, for fire protection and prisons, although the picture is mixed. In contrast, public sector outsourcing can result in quality deterioration for goods such as residential youth care and other credence goods, because their utility is difficult or impossible for consumers to ascertain. Empirical evidence suggests that not only does quality decline but also that the costs of the service increase with outsourcing. (Poutvaara, 2014) As stated above outsourcing service in public sector having a positive result in cost reduction, customer focus and to perform a good quality service. Unlike this outsourcing having a disadvantages like political crisis issue, employment of labor and high risk transfer.

2.8.2 Reasons for outsourcing

Outsourcing is a management tool and should be approached in that manner. In letting an outsourcing contract, whether for the first time or as a renewal exercise, the first step is to determine the primary reasons for the outsourcing. Organization often outsource to acquire services that are unavailable in house. While outsourcing in many cases generates savings, cost reduction however is often not the main reason. For each outsourcing contract it is important to identify the reasons for outsourcing so that these may be reflected in the development of the service requirement and in the tender evaluation process. (Outsourcing, Serving the Community By Using the Private Sector A General Guide to) (Ong, 2 July 2014)

The main reasons given by organization in the 2006 Outsourcing Survey included:

Table 2.3 Main reasons given by organization in the 2006 Outsourcing Survey

1. Unavailability of service in-house	9. policy changes
2. Focusing on core services	10. achieving defined service levels
3. Making up for staff shortages	11. improving service output
4. Access to skills	12. access to information
5. Reduction in costs	13. facilitating organizational changes
6. Flexibility in service delivery	14. Concerting fixed costs into variable costs
7. Improving service quality	15. IT legacy system support
8. Access to technology	16. Risk diversification

Source: - (Outsourcing, Serving the Community By Using the Private Sector A General Guide to) (Ong, 2 July 2014)

2.8.3 Outsourcing in Ethiopia

Outsourcing is a fashionable management technique. Despite the reasonable level of awareness of top level mangers about the concept of outsourcing, the use of outsourcing in Ethiopia has been low and highly dominated by non-core business functions such as maintenance and janitorial services, security services and information technology services. The variation in the satisfaction level of respondents regarding the outsourced services may be due to either the variation of service level provided by different service providers or the variation of expectation level of the organization (outsourcer).So far

Ethiopia in public sector has put in place a management contract for the billing system for electricity, water, & telecom service also referred as "Lehulu". (UNDP, 2012) (Mulat, July 2007)

Table 2.4 Level of service satisfaction by outsourcing at Ethiopia

Level of satisfaction	Number of Organization	Percentage
Very Satisfied	**3**	14%
Satisfied	**12**	57%
Indifferent	**3**	14%
Unsatisfied	**2**	10%
Very Unsatisfied	**1**	5%
Total	**21**	100%

Source: - (Mulat, July 2007)

2.9 Electricity utility (Distribution & Sales) service sector

Electricity services are recognized as the live blood to the nation and its development. Further, it provides the power or energy to other industries to do their functions properly and perfectly. If there is a problem in terms of power supply, whole economy is in question mark. Due to that, government should focalize electricity services as prominent and fundamental one. (Berhanu, October, 2015)

The electricity industry has three components: generation, high-voltage transmission, and low-voltage distribution. In recent years, as a result of sector reforms, supply or retailing power procurement, billing, and customer service has increasingly been considered a fourth component. A wide variety of technologies and primary energy sources are used to generate electricity. Nonrenewable sources include coal, petroleum, natural gas, and uranium; renewable sources include biomass and hydro, wind, solar, and geothermal power. Electricity distribution service quality is a critical, but sometimes neglected, aspect of distribution pricing and regulation. Service quality is an integral part of the package of services and prices that electricity users consume. (REFORMING INFRASTRUCTURE: PRIVATIZATION, REGULATION, AND COMPETITION, Restructuring Electricity Supply)

The quality of electricity supply has a range of different dimensions. Many of the key service quality measures are primarily determined by the performance of the distribution network. For example, for customers connected to the distribution network, reliability performance is mainly determined by the performance of the distribution network. Interruptions caused by generation or transmission factors are typically very low compared to interruptions caused by distribution factors. (infrastructure, August 2012)

Distribution service metrics encompass of three broad categories for measure of service they are reliability, quality of supply and customer service. (Short) (infrastructure, August 2012)

I. **Reliability:** encompasses the aspect of outages on the distribution system (excluding outages attributable to generation or transmission causes). Outages can either be planned by the network (for example, for the purpose of network construction, augmentation, or maintenance) or unplanned (e.g. due to weather, equipment faults). The focus is typically on unplanned outages.

II. **Quality of supply:** encompasses the quality of the electricity supplied over a line to a customer. Though quality of supply is sometimes defined to include outages, generally quality of supply captures situations where supply continues to a customer but varies from the normal characteristics of supply. These variations can affect the customer's experience. They can also affect the operation of electrical equipment, potentially causing permanent damage to more sensitive electrical equipment.

III. **Customer service:** covers measures of how successfully distributors have dealt with customers' problems, enquiries and requests for services. The following are aspects of customer service:

- Network contact center performance (how promptly calls are answered, the number of abandoned because there are too many prior calls in the system waiting to be answered;
- Appointment punctuality;
- Timely provision of connections;
- Maintaining street lights (average time to repair faulty street lights, and instances of delay in repairing street lights);
- Instances where the electricity distributor makes payments for not meeting guaranteed service levels;

- Providing adequate notice of any planned interruptions; and
- Complaints (reporting of the number of complaints over a range of categories, and the average time to resolve complaints for category of complaint).

2.10 Multi Criteria Decision Making (MCDM)

2.10.1 Introduction of Multi Criteria Decision Making (MCDM)

Decision Making is the act of choosing between two or more courses of action. However, it must always be remembered that there may not always be a 'correct' decision among the available choices. Multiple-criteria evaluation problems consist of a finite number of alternatives, explicitly known in the beginning of the solution process. (Hester, 2013) (Zardari)

Multiple-criteria decision-making (MCDM) or multiple-criteria decision analysis (MCDA) is a sub-discipline of operations research that evaluates multiple conflicting criteria in decision making (both in daily life and in settings such as business, government and medicine). (C.Price, February, 2015) MCDM is a set of methods which deal with the evaluation of a set of alternatives in terms of numerous, often conflicting, decision criteria. Thus, given a set of alternatives (options) and a number of decision criteria, the goal of MCDM is to provide a choice, ranking, description, classification, sorting and in a majority of cases an order of alternatives, from the most preferred to the least preferred option. (C.Price, February, 2015) MCDM can consider qualitative variables (criteria) are transformed into quantitative variables using expert-designed indicators and units. (Hester, 2013)

2.10.2 Classification of MCDM

The MCDM methods can be classified into two groups as explained in the next section. (Hester, 2013)

1. **Compensatory Method:** -A decision-making model in which choices are systematically evaluated on various criteria. Attractive attributes of an alternative can compensate for less ones-a systematic decision-making procedure has to be followed. A compensatory model because a positive score on one attribute can outweigh a negative score on another attribute. From this AHP, TOPSIS, SAW, and COPRAS categorized under compensatory methods.
2. **Outranking Methods:** -A rather different approach from any of those discussed so far has been developed in France and has achieved a fair degree of application in some continental European countries. It depends upon the concept of outranking. Outrank another if it

outperforms the other on enough criteria of sufficient importance (as reflected by the sum of the criteria weights) and is not outperformed by the other option in the sense of recording a significantly inferior performance on any one criterion. ELECTRE & PROMETHEE are considered as a part of outranking methods. (Hester, 2013)

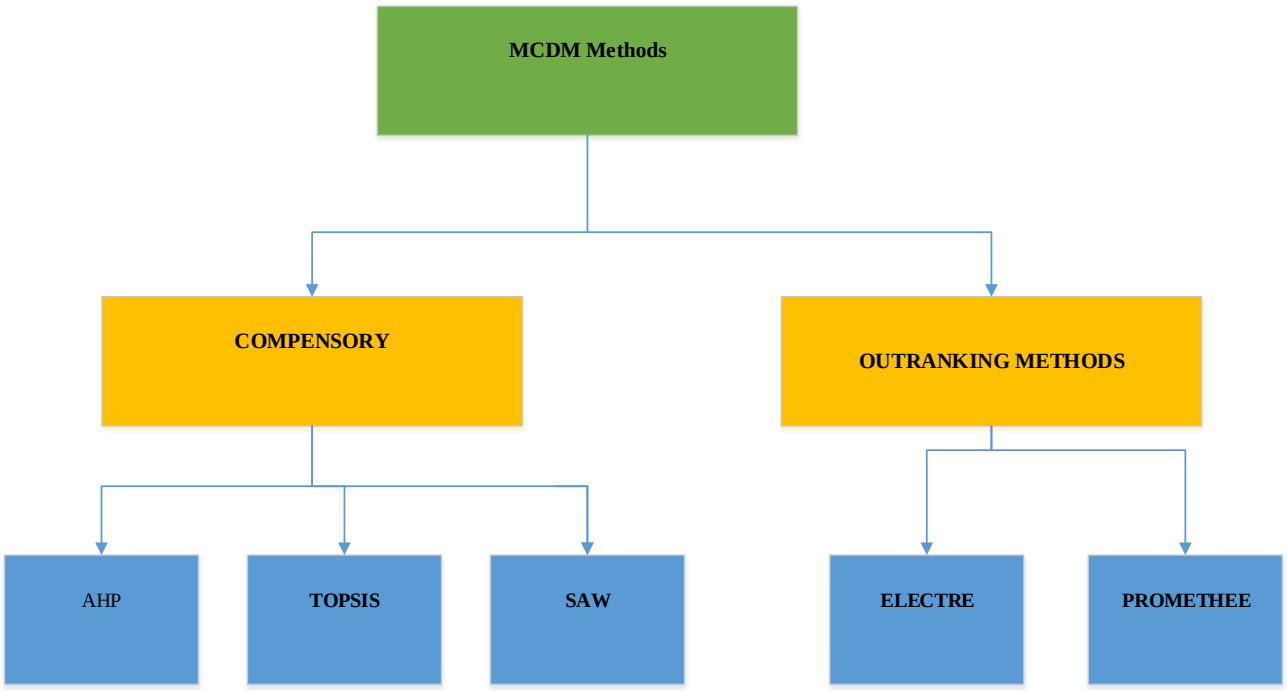


Fig 2.4 MCDM classification

2.10.3 How to select appropriate MCDM methods

According to Zardari, Abrishamchi et al. (2005) state that selecting an appropriate MCDM from a long list of available MCDM methods is a multi-criteria problem itself. There is no single MCDM method which can be superior method for all decision making problems. Different researchers have different views on this issue. Some researchers argue that different MCDM methods will yield different recommendations while some others argue that the ranking of decision alternatives is unlikely to change noticeably by using a different MCDM method provided ordinal and cardinal data are handled correctly. (Zardari)Numerous MCDM methods have been created and utilized over the last several decades. Based on the literature reviewed to their short description, the observed advantages and advantages, as well as areas of application for each method, are summarized in below.

Table 2.5 MCDM short description, field of application, advantages & Disadvantages

Method	Description	Advantages	Disadvantages	Areas of Application
Analytic Hierarchy Process (AHP)	Hierarchical structure analysis a systematic approach is followed for alternative selection and justification problem, AHP includes the opinions of experts and multi criteria evaluation. AHP is based on priority theory	Easy to use; scalable; structure can easily adjust to fit many sized problems; not data intensive.	Problems due to interdependence between criteria and alternatives; can lead to inconsistencies between judgment and ranking criteria; rank reversal.	Performance-type problems, resource management, corporate policy and strategy, public policy, political strategy, and planning.
Fuzzy Set Theory	Fuzzy logic is primarily concerned with quantifying and reasoning using linguistic expression in which words can have ambiguous meaning, vagueness issues.	Allows for imprecise input; takes into account insufficient information.	Difficult to develop; can require numerous simulations before use.	Engineering, economics, environmental, social, medical, and management.
Goal Programming (GP)	Goal programming is a division Where it has more than one objective which conflicts with each other, and by arranging the goals or target have to be achieved by minimizing the irrelevant information.	Capable of handling large-scale problems; can produce infinite alternatives.	It's ability to weight coefficients; typically needs to be used in combination with other MCDM methods to weight coefficients.	Production planning, scheduling, health care, portfolio selection, distribution systems, energy planning, water reservoir management, scheduling, wildlife management.
ELECTRE	It is used to select the best choice with maximum advantage and least conflict in the function of various criteria	Takes uncertainty and vagueness into account.	Its process and outcome can be difficult to explain in layman's terms; outranking causes the strengths and weaknesses of the alternatives to not be directly identified.	Energy, economics, environmental, water management, and transportation problems.
PROMETHEE	This method is based on mutual comparison of each alternative pair with respect to each of the selected criteria.	Easy to use; does not require assumption that criteria are proportionate.	Does not provide a clear method by which to assign weights.	Environmental, hydrology, water management, business and finance, chemistry, logistics and transportation, manufacturing and assembly, energy, agriculture.
(TOPSIS) Technique for Order Preferences by Similarity to Ideal Solutions	Assumes that each criterion has a tendency of monotonically increasing or decreasing utility which leads to easily define the positive and the negative ideal solutions.	Has a simple process; easy to use and program; the number of steps remains the same regardless of the number of attributes.	Its use of Euclidean Distance does not consider the correlation of attributes; difficult to weight and keep consistency of judgment.	Supply chain management and logistics, engineering, manufacturing systems, business and marketing, environmental, human resources, and water resources management.

Source: (Zardari) (Hester, 2013) modified

Among many multi-criteria techniques SAW, AHP, TOPSIS, SMART, ELECTRE are the most frequently used methods. The nature of the recommendations of one of those methods depends on the

problem being addressed, choosing, ranking or sorting. The selection of models/techniques can be also based on such evaluation criteria as: (Roszkowska)

- internal consistency and logical soundness,
- transparency,
- ease of use,
- data requirements are consistent with the importance of the issue being considered,
- realistic time and manpower resource requirements for the analytical process,
- ability to provide an audit trail,
- software availability, where needed

According to the above evaluation points this study selected two methods among the above, they are Analytic Hierarchy Process (AHP) and technique for Order Preference by Similarity to Ideal Solution (TOPSIS). Here below AHP & TOPSIS methods will be discussed with their analytical process.

2.11 Analytical Hierarchical Process (AHP) Decision Methods

2.11.1 Introduction of AHP method

The Analytic Hierarchy Process (AHP), introduced by Thomas Saaty is an effective tool for dealing with complex decision making, and may aid the decision maker to set priorities and make the best decision. By reducing complex decisions to a series of pairwise comparisons, and then synthesizing the results, the AHP helps to capture both subjective and objective aspects of a decision. (Kardi) In many practical cases, the linguistic assessment of human feelings and perceptions are vague and it is not reasonable to represent it in terms of precise numbers. It feels more confident to give interval judgments than fixed value judgments. Customer needs are different in nature and difficult to understand. AHP is considered as service quality measuring tools by this reason.

In addition, the AHP incorporates a useful technique for checking the consistency of the decision maker's evaluations, thus reducing the bias in the decision making process. (N.Rai, 2004)

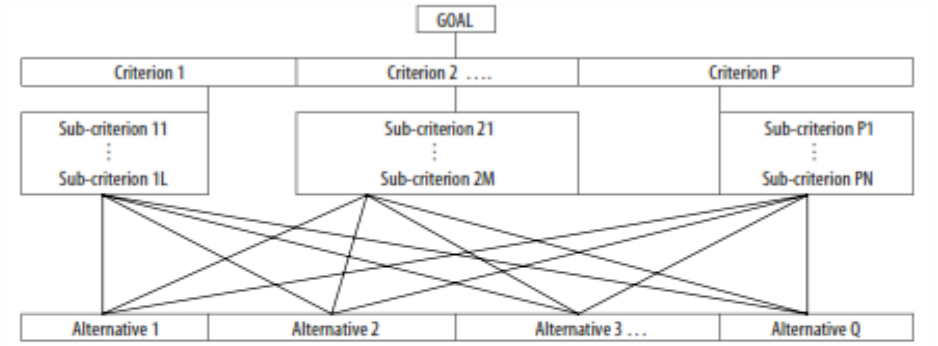


Figure 2.1 Generic hierarchic structure.

Fig 2.5: - AHP model
Source: - (N.Rai, 2004)

The AHP provides a means of decomposing the problem into a hierarchy of sub problems which can more easily be comprehended and subjectively evaluated. The subjective evaluations are converted into numerical values and processed to rank each alternative on a numerical scale. (N.Rai, 2004) (C.Price, February, 2015)

2.11.2 Justification to select & use AHP from other MCDM tools

A few reasons why AHP selected and used by this study: (Opydo, Oct 31, 2013)

1. **Intuitive and easy to use: -** People don't feel comfortable taking recommendations from software if they don't understand how it works. They don't need to know the details but they want to understand the idea behind it.
2. **Designed for multi-criteria:-** When you make important decisions, there are always conflicts between criteria. Analytic Hierarchy Process allows us to take into account all important criteria and to organize them into a hierarchy.
3. **Validates consistency: -** We are all humans and it's our prerogative to be inconsistent sometimes. We make mistakes. When we make collaborative decisions there are multiple people that can make mistakes and be inconsistent. AHP can eliminate a wonder of group decisions by aggregation method. We deliver redundant data (more than needed) and an algorithm checks to see if your input is consistent.

2.12 TOPSIS Analysis Decision methods

2.12.1 Introduction to TOPSIS method

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) was first presented by Yoon (1980) and Hwang and Yoon (1981), for solving Multiple Criteria Decision Making (MCDM) problems based on the concept that the chosen alternative should have the shortest Euclidian distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Ideal Solution (NIS). For instance, PIS maximizes the benefit and minimizes the cost, whereas the NIS maximizes the cost and minimizes the benefit. It assumes that each criterion require to be maximized or minimized. TOPSIS is a simple and useful technique for ranking a number of possible alternatives according to closeness to the ideal solution. (Srikrishna S, June-July, 2014)

The main idea of the method is to obtain the solution which is closest distance from the positive ideal solution and farthest from the negative ideal solution. TOPSIS is known as the "Technique for Order Preference by Similarity to Ideal Solution". This method is a unique technique to identify the ranking of all alternatives considered. (Güner, April 2-5, 2014)

In general here the following are the steps that we should follow during TOPSIS analysis:-

1. **The classical TOPSIS method for group decision making**

In this part we explain the detailed TOPSIS procedure for group decision making based on the Shih, Shyur and Lee proposition, (Roszkowska)

Step 1. Construct the decision matrixes and determine the weights of criteria for k-decision makers.

Let $X^k=(x_{ij}^k)$ be a decision matrix, $w^k= [w_1^k, w_2^k, \ldots., w_n^k]$ weight vector for k-decision maker or expert where $x_{ij}^k \in R, w_j^k \in R, w_1^k + w_2^k + \ldots + w_n^k = 1$ for k=1, 2, …., k.

Step 2. Calculate the normalize decision matrix for each decision maker.

In this step some of the earlier described methods of normalization can be used let us assume that we use:-

$$r_{ij}^k = \frac{x_{ij}^k}{\sqrt{\sum_{i=1}^m (x_{ij}^k)^2}}$$

Step 3. Determine the positive ideal and negative ideal solution for each decision maker.

The positive ideal solution A^{k+} for k-decision maker has the form

$$A^{k+}= \left\{\{r_1^{k+}, r_2^{k+}, \dots, r_n^{k+}\right\} = \{(max_i(r_{ij}^k)|\, j \in I), (min_i(r_{ij}^k)|\, j \in J)\}$$

The negative ideal solution A^{k-} for k – decision maker has the form:

$$A^{k-} = \{ r_1^{k-}, r_{2\,,\dots,}^{k-} r_{1n}^{k-}\} = \{(max_i(r_{ij}^k)|\, j \in I), (min_i(r_{ij}^k)|\, j \in J)\}$$

Where

I- is associated with the benefit criteria and J with the cost criteria.

Step 4. Calculate the separation measure from the positive ideal solution and the negative ideal solution.

Step 5.1. Calculate the separation measure A_i from positive ideal solution A^{k+} for each k-decision maker is given as

$$d_i^{k+} = \left(\sum_{j-1}^{m} w_j^k \ (r_{ij}^k - r_j^{k+})p\right)^{1}/_{p}\,,\ i = 1,2,\dots,m.$$

The separation of i-th alternative A_i from the negative ideal solution A^{k-} for each k-decision maker is given as

$$d_i^{k-} = \left(\sum_{j-1}^{m} w_j^k \ (r_{ij}^k - r_j^{k-})p\right)^{1}/_{p}\,,\ i = 1,2,\dots,m.$$

Where p≥ 1. For p = 2 we have the Euclidean metric.

Step 5.2 Calculate the separation measure for the group.

The aggregation for measure for the group measures of the positive ideal d_i^{*+} and the negative ideal solution d_i^{*-} for i-th alternative A_i is given by one of the operators:

Arithmetic mean

$$d_i^{k+} = \frac{\sum_{k=1}^{k} d_i^{k+}}{k} \text{ and } d_i^{k-} = \frac{\sum_{k=1}^{k} d_i^{k+}}{k}$$

Geometric mean: $d_i^{k+} = \sqrt[k]{\prod_{k=1}^{k} d_i^{k+}}$ And $d_i^{k-} = \sqrt[k]{\prod_{k=1}^{k} d_i^{k}}$

Step 6. Calculate the relative closeness to the positive ideal solution,

The relative closeness of the alternative A_i to the positive ideal solution is defined as

$$R_j^+ = \frac{d_i^{k-}}{d_i^{k-} + d_i^{k+}} \; for \; i = 1,2,\dots,m$$

Where $0 \leq R_i^+ \leq 1$.

The larger the index value, the better the evaluation of the alternative.

Step 7. Rank the preference order or select the alternative closest to 1. A set of alternative can now be ranked by descending order of the value of R_i^*.

2. The quantitative and qualitative criteria in the TOPSIS method. Weights expressed by linguistic variable

In the TOPSIS algorithm the quantitative criteria are scaled using their own real numbers and for representation of the imprecision of spatial data, and human cognition over the criteria of the theory of linguistic variables is used. A linguistic variable is a variable where values are words or sentences in a natural or artificial language. Especially, since traditional quantification methods are difficult to describe situations that are overtly complex or hard to describe, the notion of a linguistic variable is necessary and useful. We can use this kind of expression for rating qualitative criteria as well as to compare two evaluation criteria. The qualitative criterion can be described using linguistic variables; next the criteria ratings on the 1-9 number scale (Table 2.5) or on the 1-7 interval scale (Table 2.6) can be provided, respectively. (Roszkowska)

Table 2.6 the scale of alternative ratings for qualitative criterion in the case of classical TOPSIS method

Scale	**Rating**
Poor (P)	1
Medium poor (MP)	3
Fair (F)	5
Medium go0d (MD)	7
Good (G)	9
Intermediate values between the two adjacent judgments	2,4,6,8

Table 2.7 the scale of alternative ratings in the case of interval TOPSIS method

Scale	Rating
Very Poor (VP)	[0,1]
Poor (P)	[1,3]
Medium poor (MP)	[3,4]
Fair (F)	[4,5]
Medium good (MD)	[5,6]
Good (G)	[6,9]
Very good (VG)	[9,10]

Each decision maker individually uses linguistic variables transformed for numerical scale (Table 2.10) or interval scale (Table 2.11) to identify the alternative rankings for the subjective criterion. Then the rating value for group decision makers can be calculated using the following formula

$$x_{ij=\frac{1}{k}}[x_{ij}^{1} + x_{ij}^{2} + \cdots + x_{ij}^{k}]$$

Where

x_{ij}^{s} – Is the rating value of alternative A_i with respect to qualitative criterion C_j (crisp or interval) of s-decision maker (i=1, 2, …….n: j=1,2,…..m: s=1,2,……K)

In the case where the criterion weights are linguistic variables, the weights can be expressed by the 1-9 scale shown in Table 2.12. (Roszkowska)

Table 2.8 the scale of criterion weights

Scale	Weight
Very very low (VVL)	0,005
Very low (VL)	0,125
Low (L)	0,175
Medium low (ML)	0,225
Medium (M)	0,275
Medium high (MH)	0,325
High (H)	0,375
Very High (VH)	0,425
Very very high (VVH)	0,475

The vector of attribute weights must sum up to 1; if not, it is normalized. Each decision maker individually uses linguistic variables (Table 2.12) to identify the criterion weights. Then the criterion weights for all decision makers can be calculated using the following formula

$w_{r=\frac{1}{k}}\ [w_r^1+w_r^2+..+w_r^k]$,

Where :

w_r^s – Is the weight of r- criterion for s-decision maker's (r=1,2,…n; s=1,2,…,k).

Rather than the above formula, among many ways to set the weight factors are the Delphi method or the AHP method. The Delphi method is the most popular expert evaluating technique. The Delphi method is a forecasting and evaluating method both qualitative and quantitative which collects experts' ideas anonymously, exchanges and corrects this information many times to reach a consistent idea and gives the subject a final evaluation according to the experts' ideal. AHP (The Analytical Hierarchy Process) uses a hierarchical structure and pairwise comparisons.. The AHP method uses system analysis and continuously decomposes the evaluating indices according to the main evaluating indices of every level. (Roszkowska)

2.12.2 Justification to select & use TOPSIS from other MCDM tools

The main reasons to select this method are the following:-

- Simple, rational, comprehensible concept,
- Intuitive and clear logic that represent the rationale of human choice,
- Ease of computation and good computational efficiency,
- A scalar value that accounts for both the best and worst alternatives ability to measure the relative performance for each alternative in a simple mathematical form,
- Possibility for visualization.
- Availability of software or calculation templates.

2.13 Summary of literature Review

After detail reading of the literatures (annexed) which are related to this study and very help full for better understanding of the electricity quality service delivery and comparison of service delivery schemes. The researcher identified mainly two points, firstly all of them argued that there is no clear MCDM methods selection it is depending on the study matter, from methods to methods it is different in data gathering, collection & mainly in arithmetical analysis. Secondly outsourcing or privatization for public service provider will improve the service quality of the organization, but the proper management & decision making should be in account. In-house or outsourcing service delivery at EEU for greater electricity utility service? To answer the question, this study have the scientifically proven answer. So the researcher is hopeful that this study would have a contribution for further study in academic aspect and to case company consideration.

CHAPTER THREE

3. Research Design & Methodology

3.1 Introduction

This chapter described the design and methodologies which were used in the research to determine the influence of outsourcing strategy on customer perception or service quality level and how decision making will be taken by the management on outsourcing strategy by EEU.

3.2 Research Design

The research design is considered the reliability and relevance of data identification, assessing and interpretations of the level of service quality caused by the outsourcing strategy. The data gathering, analysis and the report writing process considered research ethics and unethical action strictly not in use. This research approached by descriptive method, using questionnaire and Interview, and has conducted in numerical analysis from primary and secondary data source for service quality level by outsourcing and in house service delivery.

3.3 Research Methodology

To meet the key objectives of the research, qualitative and quantitative methods and combination of primary and secondary sources of data have been used. The data gathering methods used are discussed in following sections.

3.3.1 Literature Review

To achieve the thesis objectives, the researcher conducted a broad literature review with regard to service quality improvement in electricity utility service sector, the existing improvement practice and models developed for quality improvement in the sector to help in designing the direction of the research through identifying the existing situation in our country electricity service sector. Theories in service quality, public (monopole) service quality, improvement strategy, the role of private sector for public service quality improvement and sector reform & performance indicators were also studied. The major sources of literatures were, reviewed articles, periodicals, proceedings, books, magazines,

reports and newsletters. The review helped the researcher to devise a direction for the study by analyzing the contents of the literature survey. To this end more than 17 journals and publications and 6 books have been assessed to have a clear understanding about the basic problem that underlies.

3.3.2 Data Collection

The data collection is done through: observation, interview, questionnaire and review of recorded secondary data. Benchmarking was also used to help in understanding the existing working situation in electricity service sector and provide possible solutions through discussion with EEU's managerial personnel's, quality experts, workers and customers of the sector in addition to the numerical comparison between EEU in house service and outsourced quality service.

The primary data:- are collected through questionnaire and face-to-face interview from EEU managerial personnel, EEU technical experts, EEU customers, AAU Service Quality senior experts & experts, Private sectors which are in area of electromechanical service, and Foreign aid company like power Africa, for improvement of EEUs technical service by outsourcing strategy and set of criteria question on AHP & TOPSIS model.

The secondary sources of data that the researcher used are different relevant books, Journals, Articles, senior thesis work, EEU's manuals, available documents and organizational chart and company manuals and best & recent practice in the world.

The data are collected from: Ministry of water, Irrigation & Electricity (MOWIE), Ethiopian Electric Agency (EEA), Ethiopian Electric Utility (EEU), EEU southern & Eastern Addis Ababa Region, Quality Experts, and Customer.

The detail activities accomplished to gather data are explained in following sections.

I. **Observation**: - Under this method, the information is sought by way of investigator's own direct observation without asking from the respondent. The main advantage of this method is that subjective bias is eliminated, if observation is done accurately. The researcher was used observation at EEU's branch offices, Southern Addis Ababa Regional office (found at Kazanchis) and Eastern Addis Ababa regional office(found at Kotebe) , especially in their retail & wire business department or technical department, which is responsible in operation and maintenance (technical service) of EEU with in its area of scope.

II. **Questionnaire**: - In this research, questionnaires are used to assess the level of quality service improvement in the organization (sector) by in house operation and outsourcing operation. There have been two types of questioner one for service selection using AHP & TOPSIS analysis by sector experts. Second the service quality perception from customer, EEU's employees & managers, relevant agencies like EEA & MOWIE with respect to in house and outsourced operation or service delivery. (Annex I)

III. **Interview**:- In this study, key informants are selected from EEU, MOWIE, EEA, Power Africa, Private sectors and Ministry of Public Service. Interview with the key informants from the studied and mentioned areas in Addis Ababa have been made. The interview process mostly took 25-30 minutes to complete. In this study, the interview is conducted to collect general information regarding the Ethiopian electricity service quality and the participation of the private sectors as improvement strategy, and comparison of in house & outsourced EEU service delivery. (Annex I)

3.3.3 Methods of Data Processing and Analysis

After the collection of primary and secondary data, the data analysis is followed. First, AHP method applied for decision or selection by four criteria for better service quality in comparable (alternatives of) in house service or outsourced service delivery at EEU.

Secondly, due to the time constraint and complexity of the TOPSIS analysis or calculation this study used the SANNA excel software. SANNA is a standard MS Excel add-in application that allows to analyze problems of multiple criteria evaluation of alternatives (200 alternatives is maximum). SANNA can solve MCDM problems with up to 200 alternatives and 50 criteria. Using Sanna is a simple task and decision makers can analyze quite large problems by various methods in a very short time. Sanna is a standard MS Excel add-in application that consists of five basic modules (each module corresponds to one item of Sanna menu): (Josef Jablonsky, March 2014) & (Urban)

Finally from the above two methods (AHP & TOPSIS) analysis result the researcher have draw the conclusion & recommendation based on the finding.

3.4 Research Framework

The overall research methodology and the steps followed in this research is depicted in Figure 4.1. It starts with building the data collection work and wind up with conclusions and recommendations.

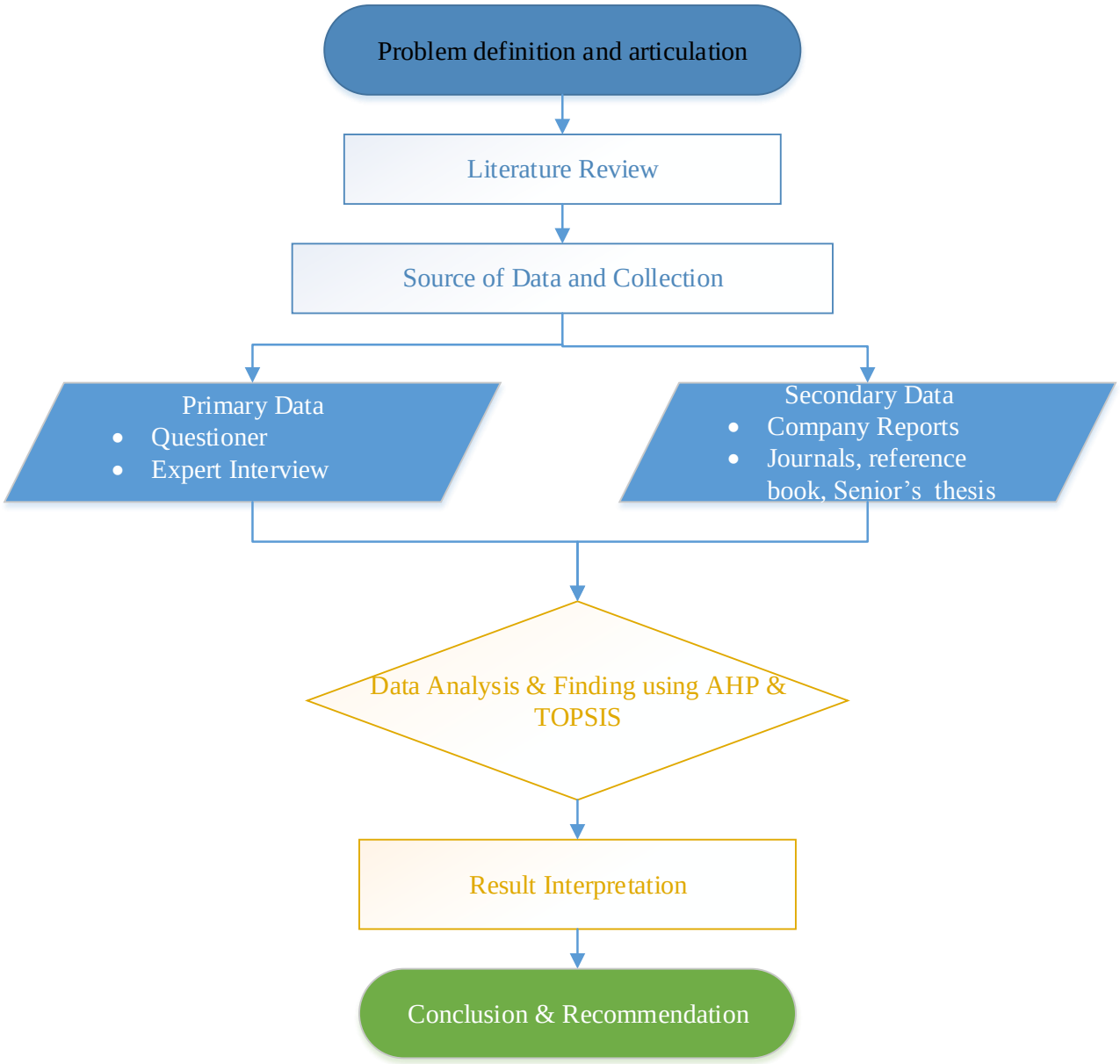


Figure 3.1: Research framework

CHAPTER FOUR

4. Overview of Service Quality at Ethiopian Public Service & Electricity Utility Service

4.1 Introduction

Governments around the world, especially those in developing countries, like Ethiopia face complex challenges in enhancing the efficiency of public service delivery. Here we will have a clear understanding of public service, its reform, additionally & Electricity service as public service and its performance indicators with respect to EEU's service with recommendable service improvement bench marks.

4.2 Public Service delivery

Public service a service which is provided by government to people living within its jurisdiction, either directly (through the public sector) or by financing provision of services. The term is associated with a social consensus (usually expressed through democratic elections) that certain services should be available to all, regardless of income, physical ability or mental acuity. Even where public services are neither publicly provided nor publicly financed, for social and political reasons they are usually subject to regulation going beyond that applying to most economic sectors. (R.Ashworth)

In modern developed countries, the term "public services" (or "services of general interest") often includes, courts, education (public schools), electricity, health care, water supply network, telecommunication, transportation facility, waste management & Social services, (e.g. public housing, social welfare, food subsidies, etc...)

In general, the public service delivery trend of the Ethiopian public service institutions can be regarded currently as inefficient. More specifically, it is characterized as time consuming, costly, incompetent, non-responsive and non-dynamic. According to Dr. Teshemo that Mr. Mengesha (2006) emphasize that "public service delivery in Ethiopia can be improved if the commitment, ownership, and the drive for change are in place." (S., June 2016,)

4.2.1 Problems of the Ethiopian Public Service in the Delivery of Services

There are several problems that contributed to poor service delivery in the Ethiopian public service. The major problems include: (Gezae Assefa, January 2017,) (S., June 2016,)

i. Positive attitude towards public service has not developed to the desired extent;

ii. Insufficient recognition that citizens have rights to receive service;

iii. Lack of accountability in public service institutions for failure to meet expected performances;

iv. Service delivery in many public institutions are based on long and time consuming, excessively hierarchical organizational structure obsolete management practice;

v. Services are in most cases provided in a manner that suits the administrative convenience of the providers rather than meet the needs of the recipients;

vi. Public service institutions are sole providers of some services;

vii. Service delivery improvement is not given sufficient attention in the planning process of many government institutions.

viii. Shortage of resources constrains improvement of services to the desired level.

4.3 Public Service Reform in Ethiopia

The service delivery reform (SDR) in Ethiopia aimed at bringing about efficiency and effectives, render better quality services and be accountable for its failure, produce committed citizen, and to bring attitudinal change towards public service delivery sub-program. Modern service delivery, which has been a distinguishing feature of the private sector, has become a typical issue among government as well as non-government institutions to transfer good management practices from the private to the public sector. Service delivery basically refers to the systematic arrangement of activates in service giving institutions with the aim of fulfilling the needs and expectations of service receivers and other stakeholders with the optimum use of resources. In short, improvement of service delivery means increasing the cost effectiveness, coverage and impact of services. Although the Ethiopian civil service has a long tradition and experience of serving various governments, it has so far given little attention to service delivery. (Wossen Woubeshet, June 2001,)

The Reform program was under the office of the Prime Minister and is designed to improve the quality of service provided by public sector employees and includes the establishment of a complaint-handling mechanism. The program, by the year 2000/1, will have made civil service institutions follow an appropriate and improved system of service delivery so as to give service to the public in an effective, efficient, transparent and impartial manner; the employees of the civil service institutions have the responsibility and obligation to provide quality service to the public fairly, equitably, honestly, efficiently and effectively.

In 2002, the Ethiopian government laid emphasis on improving efficient and effective service delivery, driven by using the new public management (NPM) Principles. The New Public Management (NPM) seeks to enhance the efficiency of the public sector, a collection more flexible strategies in terms of service delivery and human resource management. The main assumption in the NPM- reforms is that more market orientation in the public sector will lead to greater cost-efficiency for governance, without having negative side effects on other objective and considerations. (Gezae Assefa, January 2017,)

The service delivery reform as part of customer service reform (CSR) is an ongoing process practiced to date in the country. Evident to this are implementation of BPR at all levels of government organizations, BSC in majority of the federal executive agencies and regions, Reform program in Ethiopia the implementation of Sub-programs of different management performance tools like Business Process Reengineering (BPR) Balanced Score Card (BSC) & Citizens' Charter. (S., June 2016,)

At EEU two management performance tools was implemented Business Process Reengineering (BPR) and Balanced Score Card (BSC), still BSC is on implementation at EEU, from the scope of the study here not assessing the service quality due to implementation of this tools.

4.4 Electricity Service as a public service delivery and its reform in Ethiopia

4.4.1 Ethiopian Energy Sector Institutions

The key public sector institutions and entities involved in Ethiopia's electricity sector are:

1. **Ministry of Water, Irrigation and Energy (MOWIE)** - The MOWIE plans, leads, Coordinates, and monitors overall energy development. It is also responsible for capacity building in the sector, research, development and dissemination of renewable energy te chnologies and improved energy technologies. (Ministry of water, 2018) (Herscowitz)

2. **Ethiopian Electric Power (EEP)** – In November 2013 as part of an institutional reform pr ocess, the governmnt of Ethiopia split the public utility, the Ethiopian Electric Power Co rporation (EEPCo), into Ethiopian Electric Power (EEP) and Ethiopian Electric Utility (EEU). EEP focuses on project development (hydropower, in particular) and the const ruction of new transmission lines across the country. (Ministry of water, 2018) (Herscowitz)
3. **Ethiopian Electric Utility (EEU)** – Ethiopian Electric Utility (EEU) is tasked with m anaging the distribution, sales, and operations of electricity in Ethiopia. In 2013, India's P ower Grid Corporation won a two year management contract for EEU. ((EEU), 2018) (Getahun Moges, 2007)
4. **Ethiopian Energy Authority (EEA)** – The Ethiopian Energy Agency (EEA), established as an autonomous government entity in 1998 and operational since 2000, uses rules, regula tions, directives and standards to regulate energy efficiency, conservation, safety, and quality. The EEA also issues licenses, determines tariffs, and sets performance standar ds. As established in the new energy law, Proclamation 810/2013, EEA is also responsible f or negotiation of tariffs for fully offgrid independent power projects (IPPs). The EEA is ac countable to the Ministry of Water, Irrigation and Energy. (Getahun Moges, 2007) (Mengistu Tefera, 2001,) (Herscowitz)

4.4.2 Electricity Service as a Public Service Delivery

As stated above public service a service which is provided by government to people living within its jurisdiction, either directly (through the public sector) or by financing provision of services. Now a days to fulfil citizen basic needs (food, water & shelter) and additionally on health care, education transport and telecom, electricity service plays a vital role in delivery the above major service.
In previous time electricity service in our country was measured in level of access (Electrification program), there is not much attention on service quality to serve our citizen.

Ethiopian electric utility mission here given.

EEU Mission

"To be a world-class utility and contribute towards nation building by ensuring delivery of cost-effective, safe, reliable and high quality power and to enable interconnections across the African Continent for exporting surplus power. EEU shall strive towards achieving international standards of

customer care through sustained capacity building, operational and financial excellence, state-of-the-art technologies while ensuring highest standards of corporate governance and Ethics". ((EEU), 2018) Most previous studies by (Israel Behanu 2015, Daniel wendigo 2015, Zerithu Fiker 2012 & Seyoum Akele 2012) shows very poor level of service quality and poor customer satisfaction on electricity service (EEU service), by un planned outage & long recovery, very low response, poor billing system until (lehulu service at Addis Ababa), very long time for new connection in industrial and house hold level etc.

But especially in last couple of year's government puts maximum effort to enhance the level of quality service at electricity service by setting different goals, from this goals the following are major

- Digitalization information system,
- Outsource the service to private sector (not included the core process),
- New organized customer service desk,
- Enhance bill collection performance,
- Network design monitoring and quality assurance.
- Implementation of ERP (enterprise resource planning) (Dr.Ing. Getahun Mekuria, March 2017,)

4.4.3 Ethiopia Electricity Service Reform

Power Sector Reform (PSR) in Ethiopia was first preceded by a study that examined the various options for reforming the country's sole national utility, Ethiopia Electric Light and Power Authority (EELPA). The study was carried out by a task-force from EELPA, with close supervision of the Office of the Prime Minister (EELPA, 1997). The study proposed that the future public power utility should be established within a sound commercial and decentralized framework with Government providing the overarching regulatory oversight. Commercialization would aim at improving the cost-effectiveness and profitability of the activities of the national utility. (Mengistu Tefera, 2001,)

Decentralization would, on the other hand, strengthen the various regional offices of the national utility such that decision making and implementation of electricity supply activities is undertaken by regional staff without recourse to the national head office. (Mengistu Tefera, 2001,)

From this onward the next reform was held at 2007, which recognizes mainly the Sector reform, approach in the following ways: - (Getahun Moges, 2007)

A. Electricity law (§ 86/1997):

- Established the regulatory Agency EEA
- EEA Mandates:
  - determine quality and standards of electricity services,
  - Issue license; generation, transmission, distribution sales, import/export,
  - recommend tariff,
  - Issue professional competency certificate

B. Electricity Operation Regulation (§ 49/1999)

- General Licensing requirements: power generation, transmission, distribution and sales;
  - Financial capacity and technical competence,
  - Feasibility study,
  - PPA where appropriate,
  - Land permits,
- License duration maximum; from 10 to 50 years & renewable
- Rights of licensees:
  - Access to land with in service territory;
  - Service disconnection to non-compliant customer/s;
- Obligations of licensees:
  - Service operation in line with the law and regulations, standards;
  - Prompt response to new demands;
  - Regular supply;
  - Prompt response to customer's complaints;
  - Report to the regulator;
  - Avail books and records for inspection;
  - Advance notice before service interruptions;
  - Update employee skill & education necessary for the operation of licensed activity.

C. Technical regulation;

- Satisfactory and safe service for all customers;
- Service standards issued;
- Licensee define complaint handling procedure;
- Maintain complaint records & respond in 10 days,
- Customers has the right to complain to the Agency. (Getahun Moges, 2007)

4.4.4 Electricity Service Performance Indicator

Two indicators number of outages per year and number of days of delay in obtaining power connection are used to measure the quality of customer service from the customer perspective.

Customer perspective of service quality is an important indicator of utility performance. It provides feedback to the utility and, at the same time, can be used for enabling the customers to influence sector performance. Specifically important is information from customers about objective characteristics of service quality as opposed to customer perceptions. The best objective service quality indicators provided by customers and available for the African countries are number of outages per year and days of delay in obtaining power connection. These indicators are especially valuable because utility data measuring the same characteristics of utility performance are not always available or reliable in the region. (Tallaprugada, June 2009) (Short)

The service quality data are obtained from surveys of enterprises and thus are related to business customers only. However, the sampling procedure provides that these indicators can be used to evaluate overall service quality. The number of outages estimated by these surveys would be approximately the same for residential customers, as surveys use samples of businesses that have different size and are located in all areas of the country, the procedure providing for equal likelihood of experiencing outages by residential end-users. In addition, delays with obtaining electricity connection are likely to be similar or even higher for residential. (Tallaprugada, June 2009)

In other utilities electricity service reliability indices which is customer-based indices most commonly use two indices, SAIFI and SAIDI, to benchmark reliability. These characterize the frequency and duration of interruptions during the reporting period (usually years) (IEEE Std. 1366-2000). (Short)

SAIFI, System average interruption frequency index

$$SAIFI = \frac{\text{Total number of customer interruptions}}{\text{Total number of customers served}}$$

Typically, a utility's customer's average between one and two sustained interruptions per year. SAIFI is also the average failure rate. Another useful measure is the mean time between failures (MTBF), which is the reciprocal of the failure rate: MTBF in years = $1/\lambda$

SAIDI, System average interruption duration index

$$SAIDI = \frac{\text{Sum of all customer interruption durations}}{\text{Total number of customers served}}$$

SAIDI quantifies the average total duration of interruptions. SAIDI is cited in units of hours or minutes per year. Other common names for SAIDI are CMI and CMO, standing for customer minutes of interruption or outage. (Short)

From 2010 Ethiopian physical year EEU's plan the following was found,

Table 4.1 Performance Indicator at EEU

S.no	Performance Indicator of EEU	KPI Unit of measurement
1	**From Customer perspective (40%)**	
	a) Increase the number of new customer (New power connection)	Number of new customer
	b) Increase Electricity infrastructure Accessibility	Coverage Electricity in towns & Villages
2	**Financial Performance (20%)**	
	a) Increase bill collection performance	Cash flow in %
3	**Service Delivery**	
	a) Reduce EEU's internal gaps	Internal audits
	b) Improve Electricity Reliability	➢ Unplanned service outage/ Interruptions frequency(SAIFI) ➢ Unplanned service outage/Interruptions delay time (SAIDI)
	c) Methodology and occupational safety	Any death or minor/major accident
4	Learning Growth	
	a) Reduce loss	Loss of electric power in %
	b) Employees skill improvement	No. of training % or Training hours
	c) Employees ethics improvement	Decrease No. of complaints due to non-ethical employee

Source: 2010 Ec. EEU's Plan page 5-6

This research objectives also to compare the level of service quality at EEU's in house & outsourced its technical, service new connection & unplanned service outage (failure) recovery.

CHAPTER FIVE

5. Data Collection and Analysis

5.1 Introduction

To have a right decision from a given alternative proper & reliable data collection and analysis will have a vital role. In this study, data will be collected through questioner & interview from sector expertise, (experienced organization Managers) and senior customers. And analysis will be analyzed in AHP & TOPSIS procedure by following the necessary steps supported by excel software.

5.2 Data Collection

5.2.1 Determination of the sample size

There is no clear rule for AHP and TOPSIS sample size, it depends on the types of problem that we have handle and it is different from condition to condition. (Kardi) In this study, we have just assumed to get experts opinion related to sectors & organization a minimum of three and a maximum of five expert opinion.

In our country electricity utility related sector organizations are listed below table, the researcher used this organizations expert's evaluation & opinion total of twenty and average of four from each of them.

Table 5.1 Collected data and organization list

S.no	Target organization (Electricity Utility Organization)
1	Ethiopian Electric Utility (EEU)
2	Ethiopian Electric Power (EEP)
3	Ethiopian Energy Authority (EEA)
4	Ministry of Water, Irrigation and Electric (MOWIE)
5	Development Banks like, African Development Bank(ADB), World Bank (WB) Utility experts

5.2.2 Distribution, collection of the questioner and interview question

Copies of the questionnaires were distributed to collect necessary information from respondents. The researcher used one structured questionnaire for all experts and EEU's managerial personnel's to gather the data. The respondents have a number of alternative options with structural questionnaire from which they must choose the one that most closely approximates their view. The value of the study and the instructions were explained to the subjects. Respondents were requested to complete the questionnaires which were collected personally by the researcher.

5.3 Data Processing and Analysis

5.3.1 Data Processing

For the purpose of simplicity the research designate Saaty' numeric value for data collection purpose as given below:-

Table 5.2: Numeric value Designation for data collection purpose

S.No	Verbal Judgment	Saaty's Numeric Value	Designation for study
1	Equally important	1	1
2	Slightly more important	3	2
3	Strongly more important	5	3
4	Very strongly more important	7	4
5	Absolutory important	9	5

5.4 AHP (Analytical hierarchal Process) Analysis

To analyze the decision of better service quality achievement for EEU in house service or out sourced source using the analytical hierarchy process (AHP) we should follow the next steps:-

1. **Develop a modal for the decision**:- Breakdown the decision into a hierarch of goals, criteria, and alternatives
2. **Aggregate AHP result for group decision:** for group decision, many researchers recommended to use geometric mean rather than arithmetic mean for aggregation between actors. Compute the priority matrix for each survey response first then make geometric average to aggregate the results, here this study used AHP excel calculator. (Kardi)

3. **Derive Priorities (weights) for the criteria**: - The importance for criteria are compared pair wise with respect to the desired goals to derive their weights. To cheek the consistency of judgments a review of the judgment is done in order to ensure a reasonable level of consistency in terms of proportionality and resistivity.

4. **Derive Local Priorities (preferences) for the alternatives**: - Derive priorities or the alternatives with respect to each critter separately (following a similar respect to each criteria's) check and adjust the consistency as required.
5. **Drive overall priorities (model Synthesis)**:- All alternative priorities obtained are combined as weighed sum to take the weight in to account. The alternatives with the highest overall priority consists the best choice.
6. **Perform Sensitivity Analysis**: - a study of how changes in the weight of the criteria could affect the result is done to understand the rationale behind the obtained results.
7. **Making final Decision**:- Based on the sensitized result and sensitivity analysis, a decision can be made

5.4.1 Developing a Model

The first step in and AHP analysis is to build a hierarchy for the decision (as indicated in chapter two and four). And here below given AHP structure Model proposed.

The criteria is taken from key performance indicator of the electricity utility as we have discussed at chapter three, Let here remind in short,

I. Customer Service Responsiveness
II. Unplanned Service Outage (Reliability)
III. Safety (Human & home appliance)
IV. Employee's commitment

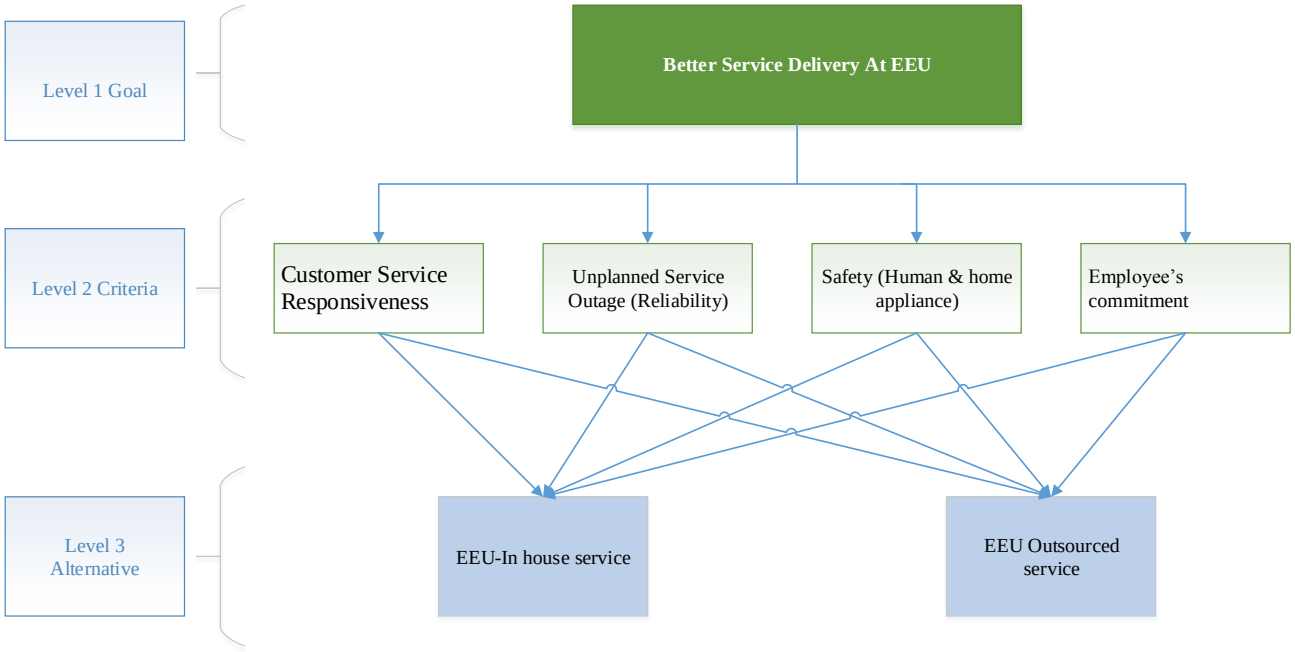


Fig. 5.1 AHP model for the making decision

5.4.2 Aggregate AHP result for group decision and Deriving Priorities (weight) for the Criteria

There are numerous group aggregation techniques that can be adapted to different group decision situations. Depending on the particular decision context, aggregation techniques differ strongly in complexity, available aid of mathematical auxiliary methods, consideration of risk or the adequate structure of the decision problem. Apart from striving for a consensus by discussion when all group members basically have similar objectives the basic consensus option is to intervene the decision making process at various stages and to aggregate either individual judgments or priorities. (Schinke, 19 July 2015)

However, the structure of the group should be analyzed prior to the application of formal aggregation techniques. In some decision settings it is appropriate to waive the assumption of equivalent group members in favor of a differentiated, relative weighting of votes. Marked differences in knowledge, experience, management level or competence between the decision makers should be reflected in their respective influences on the overall ranking of the alternatives. In order to deal with inequalities with respect to the decision power of different group members, a supra decision maker could be determined who has the competence to assign weights to each group member in an exogenous manner.

In cases where such a supra decision maker does not exist or does not seem to be acceptable for the participants, the group can try to allocate the voting power in an endogenous way. The endogenous decision power distribution could be arranged in such a way as the group is designing an additional hierarchy level to judge the relative power of each group member. Thereby, decision-relevant evaluation criteria could be decision makers' personality traits such as perceived intelligence, experience, and power or management level. All participants could then be compared according to their relative influence with respect to underlying evaluation criteria according to Saaty 1989.

Having determined the weightings $(w^r \text{ where } r = 1, \ldots, R; \sum_{r=1}^{R} w^r = 1)$ where $r = 1,..., R$; for a decision makers R, the subsequent step is the selection of an appropriate formal aggregation technique. As indicated above, the two fundamentally accepted aggregation procedures within AHP GDM are the aggregation of individual judgments (AIJ) and the aggregation of individual priorities (AIP).

In case the group structure is homogenous and decision makers are willing to act like one single individual, a synergistic AIJ is possible. Each decision maker conducts the pairwise comparisons by himself. Afterwards the (weighted) geometric mean method (WGMM) could be used to obtain the group judgment for each entry of the comparison matrices. (Saaty, 1989)

Hereby, the arithmetic mean should not be used which is due to the non-reciprocity (power conditions) of the collective pairwise comparison matrices. (Schinke, 19 July 2015) After each decision maker comes to his independent AHP based ranking, the resulting individual priorities are aggregated to a final group preference using either a (weighted) arithmetic (WAMM) or a (weighted) geometric mean method. (Saaty, 1989)

The importance or weight of each criteria will be different and because of this, we first require to derive by pairwise comparison then we will develop relative priority of each criteria with respect to each of the other using a number scale for comparison developed by Saaty as mentioned above.

Table 5.3 Criteria Importance Evaluation distribution result by respondents

S.no	Criteria	Which is Improtant for better utility service delivery (✓)	Respondat's Wieghts																			
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Customer Service Responsiveness	8	3	5	5	9	9	7	5	7	7	3	5	5	9	9	7	5	7	3	5	1
	Unplanned Service Outage (Reliability)	12									7	3	5	5	9	9	7	5	7	3	5	1
2	Customer Service Responsiveness	15	9	7	5	7	3	5	1	5	9	9	7	5	7	3	5	5	7	5	9	9
	Safety (Human & home appliance)	5																5	7	5	9	9
3	Customer Service Responsiveness	10	5	5	9	9	7	5	7	3	5	3	9	7	7	5	3	9	3	5	5	5
	Employees commitment	10											9	7	7	5	3	9	3	5	5	5
4	Unplanned Service Outage (Reliability)	13	7	9	7	3	5	3	5	9	9	7	5	7	9	7	5	3	5	7	3	5
	Safety (Human & home appliance)	7															5	3	5	7	3	5
5	Unplanned Service Outage (Reliability)	12	9	9	5	7	3	7	9	5	7	9	9	5	5	9	7	5	3	5	5	7
	Employees commitment	8													5	9	7	5	3	5	5	7
6	Safety (Human & home appliance)	11	9	9	9	7	5	9	3	7	7	9	3	5	7	7	9	3	5	7	9	9
	Employees commitment	9												5	7	7	9	3	5	7	9	9

Start analysis of the pair wise comparison, priority and consistency, as stated above we have to evaluate each survey of respondent, and take their geometric mean of the result obtained from each matrix analysis. The study sample size is twenty it will be very difficult and time taking to calculate each matric by own excel. The researcher found the AHP calculator excel which is up to 20x20 matrix (Annex III) from internet to aggregate the overall respondent decision by geometric mean of each survey matrix analysis. (19/2018)

Using the excel tablets, here below table shown the results of aggregation of group (20) respondent decision.

Table 5.4 AHP group aggregation matrix result.

Better service Quality at EEU	Customer Service Responsiveness	Unplanned Service Outage (Reliability)	Safety (Human & home appliance)	Employees commitment
Customer Service Responsiveness	1.0000	0.7924	2.1234	1.0000
Unplanned Service Outage (Reliability)	1.2620	1.0000	2.2902	1.5782
Safety (Human & home appliance)	0.4709	0.4366	1.0000	1.2143
Employees commitment	1.0000	0.6336	0.8235	1.0000

Continue to the weight calculation the following result found (already checked and correct, by the sum of all weights should come 1.00)

Table 5.5 AHP group aggregation weight result.

Better service Quality at EEU	Customer Service Responsiveness	Unplanned Service Outage (Reliability)	Safety (Human & home appliance)	Employees commitment	Priority	Importance in %
Customer Service Responsiveness	0.2679	0.2768	0.3404	0.2087	0.2734	**27.34%**
Unplanned Service Outage (Reliability)	0.3381	0.3493	0.3672	0.3293	0.3460	**34.60%**
Safety (Human & home appliance)	0.1262	0.1525	0.1603	0.2534	0.1731	**17.31%**
Employees commitment	0.2679	0.2213	0.1320	0.2087	0.2075	**20.75%**

Continued from this we can summarize the result in table as follows:

Table 5.6 Summary of criteria weight with aggregated matrix value

Better service Quality at EEU	Customer Service Responsiveness	Unplanned Service Outage (Reliability)	Safety (Human & home appliance)	Employees commitment
Criteria Weights	**0.2748**	**0.3463**	**0.1724**	**0.2064**
Customer Service Responsiveness	1.0000	0.7924	2.1234	1.0000
Unplanned Service Outage (Reliability)	1.2620	1.0000	2.2902	1.5782
Safety (Human & home appliance)	0.4709	0.4366	1.0000	1.2143
Employees commitment	1.0000	0.6336	0.8235	1.0000

which shows unplanned service outage is score higher percentage 34.63%, followed by customer service responsiveness 27.48%, third level employees commitments 20.64% and lastly safety (human & home appliance) scored least 17.24%. This criteria weights means that, from EEU's electricity utility service, unplanned service outage (in numbers & frequency of occurrence) is very important from other with 34.63%, customer service 27.48%, employees commitments 20.64% & safety 17.24% with their level of importance for better service delivery. This looks like related to the current scenario of EEU's service delivery which indicates unplanned outage and customer service are the most critical service needs improvements

5.4.3 Consistency

Once judgments have been entered, it is necessary to check that they are consistent. Since the numeric values are derived from the subjective preferences of individuals, it is impossible to avoid some inconsistencies in the final matrix of judgments. The question is how much inconsistency is acceptable. For this purpose, AHP calculates a consistency ratio (CR) comparing the consistency index (CI) of the matrix in question (the one with our judgments) versus the consistency index of a random-like matrix (RI). A random matrix is one where the judgments have been entered randomly and therefore it is expected to be highly inconsistent. More specifically, RI is the average CI of 500 randomly filled in matrices. (Kardi) Saaty (2012) provides the calculated RI value for matrices of different sizes as shown below.

Table 5.7 Consistency indices for a randomly generated matrix (Kardi)

n	3	4	5	6
RI	0.58	0.9	1.12	1.24

In AHP, the consistency ratio is defined as CR where CR = CI/RI. Saaty (2012) has shown that a consistency ratio (CR) of 0.10 or less is acceptable to continue the AHP analysis. (Saaty, 1989) If the consistency ratio is greater than 0.10, it is necessary to revise the judgments to locate the cause of the inconsistency and correct it.

Table 5.8 Weighted sum of the matrix

Better service Quality at EEU	Customer Service Responsiveness	Unplanned Service Outage (Reliability)	Safety (Human & home appliance)	Employees commitment	Weighted Sum
Customer Service Responsiveness	0.2748	0.2744	0.3661	0.2064	1.1218
Unplanned Service Outage (Reliability)	0.3468	0.3463	0.3948	0.3258	1.4138
Safety (Human & home appliance)	0.1294	0.1512	0.1724	0.2507	0.7037
Employees commitment	0.2748	0.2195	0.1420	0.2064	0.8427

Calculation of λmax, Table 5.9 calculation of λ (lamda)

Weighted Sum	Priority	Weighted sum/priority
1.1218	0.2748	4.08198
1.4138	0.3463	4.08198
0.7037	0.1724	4.08198
0.8427	0.2064	4.08198
	Total	16.3279

Divide the total by 4 to obtain λmax=	4.0820

Consistency Index (CI)

CI = (λmax-n)/(n-1) =(4.0820-4.000)/(4-1)= 0.027327

CR=CI/RI=0.027327/0.9=0.030363 =3% where RI is 0.9 for n=4

It is less than 0.1 we can assume our judgement is reasonably consistent, we can proceed to our AHP Analysis

5.4.4 Derive Local Priorities (preferences) for the alternatives

Derive priorities or the alternatives with respect to each criteria separately (following a similar respect to each criteria's) check and adjust the consistency as required.

From questioner the following data was found, its value and distribution

Table. 5.10: Expert rating value for preference data distribution

S.No	Criteria	Which alternatives are preferred? Put (√) on your choice		Expert rating value																				
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	With respect to customer service Responsivness	EEU In-house Service	4	5	9	5	9																
		Out-Sourced EEU Service	16					9	9	7	9	5	5	5	5	9	9	7	9	5	5	5	5
2	With respect to unplanned service outage (Relaibility)	EEU In-house Service	10	7	7	9	5	1	7	7	9	5	1										
		Out-Sourced EEU Service	10											5	3	5	7	9	5	3	5	7	9
3	With respect to Safety (Human & Home Appliance)	EEU In-house Service	2	5	5																		
		Out-Sourced EEU Service	18			9	9	9	5	5	3	5	9	9	9	9	9	5	5	3	5	9	9
4	With respect to employees Commitment	EEU In-house Service	4	7	5	5	7																
		Out-Sourced EEU Service	16					9	9	9	9	5	5	5	5	9	9	9	9	5	5	5	5

As it is mentioned in above, we have to check the preference of the alternatives with respect to each criteria. Shown in below table summary. This also calculated by the same AHP excel calculator, from each respondent decision and take the geometric mean of the aggregated result.

Table 5.11 Criteria Vs Alternatives for preference.

s.no	Criteria	Alternatives
1	With respect to customer service Responsiveness	EEU In-house Service
		Out-Sourced EEU Service
2	With respect to unplanned service outage (Reliability)	EEU In-house Service
		Out-Sourced EEU Service
3	With respect to Safety (Human & Home Appliance)	EEU In-house Service
		Out-Sourced EEU Service
4	With respect to employees Commitment	EEU In-house Service
		Out-Sourced EEU Service

I. With respect to customer service Responsiveness

Table 5.12, Result of priority with respect to Customer service Responsiveness

Result with respect to customer service responsiveness			
Priority	EEU In-house Service	Out-Sourced EEU Service	Priority
EEU In-house Service	1.0000	0.3273	0.2465
Out-Sourced EEU Service	3.0553	1.0000	0.7531

II. With respect to unplanned service outage (Reliability)

Table 5.13 Result of priority with respect to unplanned service outage (reliability)

Result with respect to Unplanned service outage			
Unplanned service outage (Reliability)	EEU In-house Service	Out-Sourced EEU Service	Priority
EEU In-house Service	1.0000	0.9266	0.4807
Out-Sourced EEU Service	1.0792	1.0000	0.5188

III. With respect to Safety (Human & Home Appliance)

Table 5.14 Result of priority with respect to safety (human & home appliance).

Result with respect to Safety (human &home appliance)			
Safety (Human & Home appliance)	EEU In-house Service	Out-Sourced EEU Service	Priority
EEU In-house Service	1.0000	0.2165	0.1779
Out-Sourced EEU Service	4.6198	1.0000	0.8218

IV. With respect to employees Commitment

Table 5.15 Result of priority with respect to employee commitment.

Result with respect to Employee's Commitment			
Employees Commitment	EEU In-house Service	Out-Sourced EEU Service	Priority
EEU In-house Service	1.0000	0.3113	0.2373
Out-Sourced EEU Service	3.2128	1.0000	0.7624

Local Priority (preference) of the alternatives with respect to each criterion, or summary of priority.

Table 5.16 Local priority of the alternatives with respect to each criteria.

Local Priority (preference) of the alternatives with respect to each criterion				
Alternatives	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human &Home Appliance)	Employee's Commitment
EEU In-house Service	0.2465	0.4807	0.1779	0.2373
Out-Sourced EEU Service	0.7531	0.5188	0.8218	0.7624

From this result, all criteria except unplanned service outage the preference value have a greater difference. But on the unplanned service outage it is very closer to each other.

5.4.5 Drive overall priorities (model Synthesis)

All alternative priorities obtained are combined as weighed sum to take the weight in to account. The alternatives with the highest overall priority consists the best choice. Like above using criteria weights multiplied all cells with it and sum in row side, note column as previous.

Table 5.17 Preparation calculation of weighing for priority.

Preparation for weighing of priorities

Alternatives	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human &Home Appliance)	Employee's Commitment
Criteria Weights	**0.2748**	**0.3463**	**0.1724**	**0.2064**
EEU In-house Service	0.2465	0.4807	0.1779	0.2373
Out-Sourced EEU Service	0.7531	0.5188	0.8218	0.7624

Synthesis of the model/original Analysis

Table 5.18 Result of overall priority, showed that Out-sourced EEU service 68.57% & In-house 31.39%

Synthesis of the model/original Analysis					
Alternatives	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human &Home Appliance)	Employee's Commitment	Overall Priority
Criteria Weights	**0.2748**	**0.3463**	**0.1724**	**0.2064**	
EEU In-house Service	0.2465	0.4807	0.1779	0.2373	0.3139
Out-Sourced EEU Service	0.7531	0.5188	0.8218	0.7624	0.6857

5.4.6 Sensitivity Analysis

A study of how changes in the weight of the criteria could affect the result is done to understand the rationale behind the obtained results. And leads the decision maker to have different looks.

The overall priorities will be heavily influenced by the weights given to the respective criteria. It is useful to perform a "what-if" analysis to see how the final results would have changed if the weights of the criteria would have been different.

This process is called sensitivity analysis and constitutes the fifth step in our AHP methodology. Sensitivity analysis allows us to understand how robust is our original decision and what are the drivers (i.e., which criteria influenced the original results). This is an important part of the process and, in general, no final decision should be made without performing sensitivity analysis.

Sensitivity analysis is having three scenario for preforming the analysis; given below.

I. Original scenario-synthesis of the model (Table 5.18)

Synthesis of the model/original Analysis					
Alternatives	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human &Home Appliance)	Employee's Commitment	Overall Priority
Criteria Weights	**0.2748**	**0.3463**	**0.1724**	**0.2064**	
EEU In-house Service	0.2465	0.4807	0.1779	0.2373	0.3139
Out-Sourced EEU Service	0.7531	0.5188	0.8218	0.7624	0.6857

II. All criteria have the same weight

Table 5.19 Result of sensitivity analysis if all criteria is having equal weight.

Alternatives	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human &Home Appliance)	Employee's Commitment	Overall Priority
Criteria Weights	**0.2500**	**0.2500**	**0.2500**	**0.2500**	
EEU In-house Service	0.0616	0.1202	0.0445	0.0593	0.2856
Out-Sourced EEU Service	0.1883	0.1297	0.2055	0.1906	0.7140

III. **From original synthesis of the model, keep equal preference value (50%) for the highest score of criteria weight.**

From original synthesis, out-sourced is preferred with the highest 73% at Safety criteria. So here we have to make safety 50% and check the result.

Table 5.20 Result of sensitivity analysis for second scenario, and found out-sourced 75% & in-house 24.97%.

Alternatives	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human &Home Appliance)	Employee's Commitment	Overall Priority
Criteria Weights	**0.1667**	**0.1667**	**0.5000**	**0.1667**	
EEU In-house Service	0.2465	0.4807	0.1779	0.2373	0.2497
Out-Sourced EEU Service	0.7531	0.5188	0.8218	0.7624	0.7500

5.4.7 Making a final Decision

Based on the sensitized result and sensitivity analysis, a decision can be made. Once the above steps have been completed, it is now possible to make a decision. This constitutes the last step in our AHP analysis. For this, it is necessary to compare the overall priorities obtained and whether the differences are large enough to make a clear choice. It is also necessary to analyze the results of the sensitivity analysis (Tables 2.16, 2.17 and 2.18). From this analysis, the result express as follows:

Table 5.21 Final decision result, shown the out-sourced EEU's service is preferred.

	Making a Final Decision		
S.no	**Scenarios for final decision**	**Selected Alternatives**	**Percentage (%)**
1	Original scenario-synthesis of the model	Out-Sourced	68.57%
2	Scenario II, All criteria have the same weight	Out-Sourced	71.40%
3	Equal preference (0.5) will be given at the high score of its preference at original model.	Out-Sourced	75.00%

5.5 TOPSIS Analysis

As mentioned at previous chapter due to the time constraint and complexity of the TOPSIS calculation this study used the SANNA excel software application, that allows to analyze problems of multiple criteria evaluation of alternatives (200 alternatives is maximum). (Urban)

The first step is determining the decision matrix values and criteria weights for group decision makers by developing aggregated matrix for rating values. Using formula

$$x_{ij=\frac{1}{k}}[x_{ij}^{1} + x_{ij}^{2} + \cdots + x_{ij}^{k}]$$

From Table. 5.10, Expert rating value for preference data distribution, Here let X11 (the rating value of customer service responsiveness with respect to EEU's In-house service) calculate as follows: X11=1/4(5+9+5+9) =7 and the same to all other. Regarding weights of criteria already it was calculated at AHP analysis we can use that one. So here the consolidated rating values and weight is given in the below table.

Table 5.22 Weight of criteria and alternatives preference rating values.

Data Processing for TOPSIS Analysis				
Better service delivery at EEU	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human & Home Appliance)	Employee's Commitment
EEU In-house Service	X_{11}=1/4(5+9+5+9) =7	5.8000	5.0000	6.0000
Out-Sourced EEU Service	6.7500	5.8000	7.0000	7.0000
Weights from AHP	0.2748	0.3463	0.1724	0.2064

Secondly, this data have filled at Sanna excel software and continue the analysis here below given each steps:-

I. **Data managements: -** SANNA works with standard .xls worksheets. Input data information of the decision problem with the criterion matrix is placed in this worksheet in the sheet named "data". Data management module either opens new data sheet (if does not already exists) based on specification of the basic parameters of the problem (the number of alternatives and criteria) or deals with the current data sheet. In this study case four criteria and two alternatives.

And the criteria have to be categorized as Max/Min or benefits criteria the greater values being better, whereas the cost criteria the smaller values are better.

In our case here customer service responsiveness, safety (Human &Home Appliance) and employee's commitment are benefit criteria, whereas unplanned service outage (Reliability) considered as cost criteria.

As stated above the data filled as given below:-

Table 5.23 Encoded data at Sanna

	MAX	MIN	MAX	MAX
Better Service quality at EEU	Customer service Responsiveness	Unplanned service outage (Reliability)	Safety (Human &Home appliance)	Employee's Commitment
EEU In-house Service	7.0000	5.8000	5.0000	6.0000
Out-Sourced EEU Service	6.7500	5.8000	7.0000	7.0000
Weights	**0.27481**	**0.34635**	**0.17240**	**0.20644**

II. **Non-dominance filter:** - This module makes it possible to test the non-dominance of alternatives in the current data set. The alternatives are marked according to the results of the test as dominated or non-dominated. Another feature of the module is the possibility to remove the dominated alternatives from the data set. The result of this study dominance is given in below table:

Table 5.24 Dominance test result

	max	min	max	max	
	Customer service Responsivness	Unplanned service outage (Relaibility)	Safety (Human &Home Aplliance)	Employees Commitement	Test
EEU In-house Service	7.0000	5.8000	5.0000	6.0000	Non-dominated
Out-Sourced EEU Service	6.7500	5.8000	7.0000	7.0000	Non-dominated
Weights	**0.27481**	**0.34635**	**0.17240**	**0.20644**	

III. **Estimation of weights module:** - The decision maker can specify the weights of the criteria either directly by their setting in the data sheet or by means of three simple well-known methods supported by estimation of weights module. The decision maker can use the following techniques:

- Scale method (weights are set in any numerical scale and normalized), this study follows this.
- Fuller method (based on paired comparisons of the criteria and selection one of the following: one of the criteria is more important or both the criteria are equally important),
- AHP (based on the standard Saaty's scale) – uses either eigenvector calculation or logarithmic least square method (approximation of the eigenvector); the consistence of the comparison matrix is checked.

The estimation weights module contains the function that transmits the weights calculated by above mentioned methods into the data sheet and the function than graphically presents the weights.

IV. **Methods for multi criteria evaluation of alternatives:** - The current version of the SANNA system supports five basic methods for multi criteria evaluation of alternatives (WSA, TOPSIS, ELECTRE I, PROMETHEE I, II and MAPPAC). All the methods need the knowledge of the weights of the criteria. ELECTRE and PROMETHEE class methods require specification of some additional parameters. This study used TOPSIS, shown below three table, Table 5.24 TOPSIS methods selection with its analysis from (table A-C)

Table 5.24 A, which shows the modified data meaning it will check either it is as the analysis format or not, value of raw data will not change.

Modified input data:

	MAX	MIN	MAX	MAX
	Customer service Responsivne ss	Unplanned service outage (Relaibility)	Safety (Human &Home Aplliance)	Employees Commiteme nt
EEU In-hous	7.0000	5.8000	5.0000	6.0000
Out-Sourced	6.7500	5.8000	7.0000	7.0000
Weights	**0.27481**	**0.34635**	**0.17240**	**0.20644**

Table 5.24 B Normalized criteria matrix

Normalised criterion matrix R:

	MAX	MIN	MAX	MAX
	Customer service Responsivne ss	Unplanned service outage (Relaibility)	Safety (Human &Home Aplliance)	Employees Commiteme nt
EEU In-hous	0.71984	0.70711	0.58124	0.65079
Out-Sourced	0.69414	0.70711	0.81373	0.75926
Weights	**0.27481**	**0.34635**	**0.17240**	**0.20644**

Table 5.24 C Weighted criteria matrix

Weighted criterion matrix W:

	MAX	MIN	MAX	MAX			
	Customer service Responsivne ss	Unplanned service outage (Relaibility)	Safety (Human &Home Aplliance)	Employees Commiteme nt	di+	di-	ci
EEU In-hous	0.19782	0.24490	0.10021	0.13435	**0.04591**	**0.00707**	**0.13336**
Out-Sourced	0.19076	0.24490	0.14029	0.15674	**0.00707**	**0.04591**	**0.86664**
Weights	**0.27481**	**0.34635**	**0.17240**	**0.20644**			
Ideal	**0.19782**	**0.24490**	**0.14029**	**0.15674**			
Basal	**0.19076**	**0.24490**	**0.10021**	**0.13435**			

The ideal solution represents that which provides the maximum benefit as determined on the basis of a composite of the best performance values in the matrix (0.19782, 0.24490, 0.14029, and 0.15674). The nadir (basal) solution represents that which provides the least benefit, which is a composite of the worst values in the matrix (0.19076, 0.24490, 0.10021, and 0.13435). The proximity of the alternatives to the ideal solution di+ and the nadir solution di- can be obtained using the square root of the squared distances in the imaginary attribute space given in equation (As stated on chapter two of 2.12). But here the SANNA itself calculated the values mentioned above.

$$d_i^{k+} = \sqrt[k]{\prod_{k=1}^{k} d_i^{k+}} \text{ And } d_i^{k-} = \sqrt[k]{\prod_{k=1}^{k} d_i^{k}}$$

V. **Analysis Reporting:** - The successfully completed evaluation by any of the methods adds a new sheet into the active worksheet with basic information about the results. By report wizard

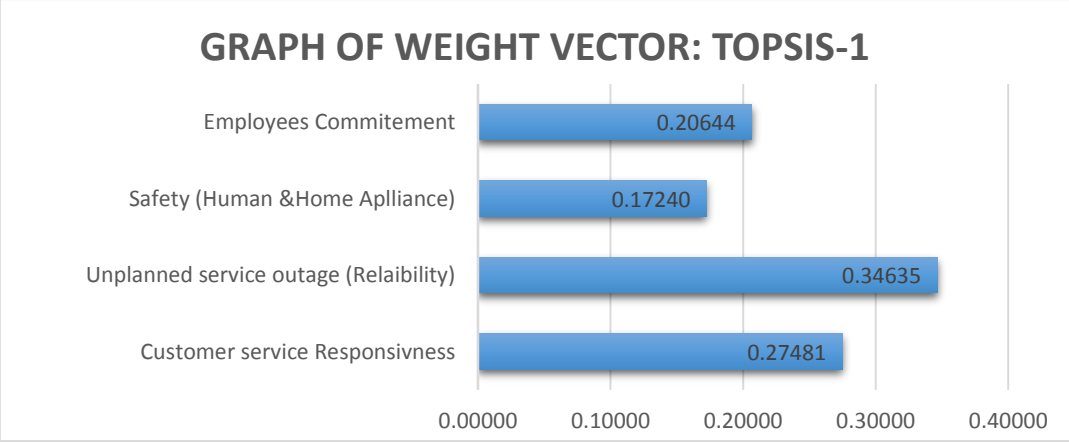
the user of the application can build his own output sheet with the results in the user-defined form.

From this study analysis the following report is given:-

A. Graph of weight vector
B. TOPSIS graph of alternatives with utilities
C. Final Ranking

A. Graph of weight vector

Table 5.25 Graph of weight vector

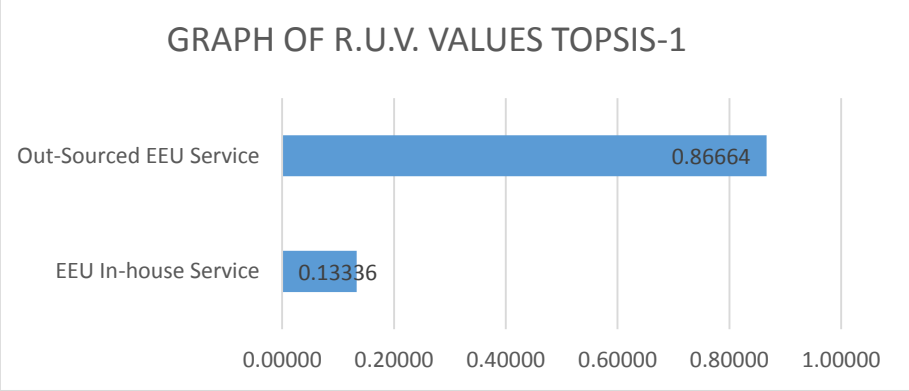


Since the study used AHP weight value, so here doesn't have any change from previous one.

B. TOPSIS graph of alternatives with utilities values

The R.U.V value describes the relative distance of the alternative (relative utility value) from the basal alternative ci. The report show EEU In-house service, utility value (0.13336) and Outsourced service, utility value (0.86664). As given above on table 5.24

Table 5.26 Graph of R.U.V. values topsis-1



C. Final Ranking

Rank the preference order or select the alternative closest to 1. A set of alternative can now be ranked by descending order of the value of R_i^*.

Table 5.27 Final ranking

Ranking	Alternative	R.U.V
1	**Out-Sourced EEU Service**	**0.86664**
2	**EEU In-house Service**	**0.13336**

So here from result shown, Rank the preference order or select the alternative closest to 1, Out-sourced service of EEU is selected. (0.86)

5.6 Summary of Results

The summary of the results from data analysis (primary & secondary data analysis) are given as follow:-

I. Results from primary (questioner) data

For the preference of better quality service delivery from alternatives of EEU's in-house and outsourced technical service delivery, the result from AHP and TOPSIS given a greater preference to outsourced technical service delivery. AHP gives above 70% preference and TOPSIS gives 86.67% preference to outsourced technical service from alternatives for improvement of quality service at EEU.

In additional to this result, the criteria weight result shows in a better quality service delivery at EEU technical service, from all four criteria which is given in this study gives a higher percentage for unplanned service outage/recovery (34.6%), meaning frequency of unplanned service outage and short recovery time needs a high attention from the service part and this part will enhanced its quality of service using outsourced service delivery. Second higher 27.5% is given for customer service (responsiveness), which the complaint and any needs of customers has to be attained in outsourced service delivery scheme. Employee's commitment (20.6%) and safety in human (17.2%) has given from criteria weight.

General result using AHP & TOPSIS, shows that better quality service delivery at EEU can delivered by outsourcing. This implies that the quality service for EEU's technical service can be improved from current EEU in-house service. This makes the organization to meet the customer requirements.

II. Interview result

From face to face interview, almost (>90%) of the respondents preferred that EEU's technical service (Operation and Maintenance) will be enhanced from the current in-house operation by out sourcing (contracting). Even though some of them are in doubt of its political implication since this service has been in monopoly in our country's experience. Most of utility experts, stated that creating a competitive environment will have a great impact on the service quality.

One of the respondent was EEU's Board Chairman, pointed out EEU strategically moving on decentralization of its service either in technical service or in other its operation. From these direction private sector will taking a big share in infrastructure (construction) stage and Operation & Maintenance. He reply to performance comparison of current EEU operation and outsourced service, "both of them are having their own merits & demerits but in customer oriented service point of view (civilized service), out-sourcing alternative will be preferable even though it need proper study and benchmark."

Finally, most of the respondents agreed that placing outsourcing in Operation and Maintenance will lead EEU to effectiveness and efficiency in service delivery improvement on performance of the organization and has aid for improving customer needs.

III. Observation result

Ethiopian electric utility southern Addis Ababa region office (found at Kazanchis) and East Addis Ababa region office (found at Kotebe) was my sample targets for observation data collection.

The main responsibility of this offices are avail a reliable electricity service and serve a customer service by their respective retail & wire business department (technical dept.) with in their scope of area. During my frequent visits to both regional office the following were observed:

i. One of their similarity is very long queue of their customer in the compound, in scarce of service delivery. Mainly customers comes to this office due to unplanned service outage recovery compliant.

ii. In both office operation customer service was observed very weak. Some of the office employee's lacks discipline (not ethical), less responsibility due to lack of monitoring system & transparency in customer complaint handling.

iii. From both office, it was observed that, no systematic operational procedures and manual for monitoring purpose. For instance just one customer has registered the compliant on 905 call center. But the problem here is the operator /concerned call center personnel's can only transfer to retail & wire business section. There is no counter checking mechanism, or coordinated process in addressing the complaint.

CHAPTER SIX

6. Conclusions and Recommendations

6.1 Conclusions

In assurance of national economic growth reliable electricity service plays vital role in every country. From the current EEU' in-house service delivery there are complaints of poor service delivery especially regarding the technical service delivery. As per this research, outsourcing this technical service would place EEU an effective and efficient service delivery position comparing with current service delivery.

The study found out that outsourcing leads to effectiveness in service delivery, promotes efficiency, improve organizational performance, allows effective resources allocation in addressing customer needs, and enables the organization to strategically procure services that serve the needs of the customers directly and aiding the company to focus on its strategic development process.

Both qualitative and quantitative descriptions were applied on the data gathered to analyze the information obtained. By undertaking a detailed analysis of the situation, the following points are concluded.

- For meeting EEU's customer expectation at its technical service (Operation & Maintenance), as per analysis held more than 75% preference is given to out sourced service delivery model. This gives assurance in improvement of the service delivery from current one. Service delivery will be highly impacted, in unplanned service outage, customer service, complaint handling, and timely new connection by outsourcing the technical service. This will makes EEU's service near to customer expectation.
- On selection of out-sourced model can concluded, Unplanned service outage (reliability), customer service (responsiveness), employee's commitment & safety issues should be addressed by the service provider (EEU) for his current operation. Since most of the dissatisfaction is going on in this area.
- Outsourcing this utility service will create employment opportunity at the country, since the service qualification is meeting TVT graduates. Training & support may require from EEU.

6.2 Recommendations

From the result and conclusion above for EEU's service delivery improvement, the following recommendations are forwarded:-

1. EEU's technical service quality improvement from current in-house service delivery has been assured by outsourcing (contracting out) this technical service (operation &maintenance) to the third party. Due to creation of competitive environment and contractual obligation outsourcing will for improvement the service quality. So that the company will strive to exceed the customer expectations.

2. EEU has a mission of being a world class utility and contribute towards national building by ensuring delivery of cost effective, safe, reliable and high Quality power. EEU strive towards achieving international standard of customer came through sustained capacity building operation and financial excellence. But to achieve this, EEU has to operate under competitive environment, that is through outsourcing (contracting) its operation and Maintenance.

3. For unplanned service outage recovery, compliant handling and new connection process and procedure, EEU should review operation with concerned stakeholders. Pre-determined service standard should be in place to control service quality and performance in–house & outsourced service. From my observation; there is no clear procedure and pre-determined service standard for some activities. So this will show the performance of each task and to get corrective action on weak performance to satisfy its customers as well as reward its employees and contractors based on performance measures. .

4. Incentives and rewarding mechanism towards efficient employees will assure quality service delivery, this recommended for EEU's in-house service delivery. For instance, there show be awarding scheme for the manager and his subordinates which having least number of customer complaints, least time service outage and recovery and no minor accident at his operation.

5. Since there is no safety policy in place so far, EEU has to develop a safety policy with target zero death and least minor accidents. Create good awareness through training to the employees will improve the organization's safety issues. And providing the employees with good PPE (personal protective equipment) is mandatory.

6. The company (EEU) should develop a good skill on contract administration, for monitoring and controlling of outsourced service quality. There should be a periodic review and customer survey feedback from both service area which is in-house and outsourced service. Beside this technological advancement can makes the monitoring and controlling mechanism. Like the 905 call center, every customer complaint should be registered to create accountability and responsibility on both service delivery.

7. The management should keenly monitor the outsourcing so as to have an overall picture about the service delivery process. This will ensure that the vendors do not use low quality workmanship which might lead to low quality services to the customers leading to losses.

8. The company should enforce tougher penalties for illegal user of electricity and on the vandals of public properties. Customer has the responsibility to install necessary protective equipment to limit the adverse effect of power quality problem and to reduce loss, like power factor corrector, adaptor, lighting protector system.

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Annex I Questionnaire & Interview Question

Questionnaire-1

Addis Ababa Institute of Technology
School of Graduate Studies
School of Mechanical and Industrial Engineering

Questionnaire on Selection of In-house & outsourced EEU's service for Quality Improvement – Part I

Dear Participant,

I am Endale Alemayehu, working on my MSc of Industrial Engineering thesis entitled "Assessment of Service Quality Improvement at Ethiopian Electric Utility (EEU) By Out-Sourcing Its Technical Service" in Addis Ababa Institute of Technology (AAiT), School of Mechanical and Industrial Engineering. My Advisor is Dr. Ameha Mulugeta and Co-Supervisor is Ato Assefaw Regassa (PhD Candidates) from Addis Ababa Institute of Technology.

As Part of my study, I am working on the way public utility service quality improvement especially in electricity sales & distribution in the case of Ethiopian Electric Utility (EEU). In addition on comparison of EEU's in house service & outsourced service in the service delivery of the Ethiopian electric utility. Thus, as an aid to assess the experts', customers' & employees' perception regarding the service delivery improvement given by EEU in house service delivery & outsourced.

I would like to extend my gratitude to you & your organization and the staff for the willingness and cooperation in undertaking this valuable research and give information regarding the existing working situation & service improvement through outsourced as well as problems(if any) that the company is facing. I request your compassionate cooperation in answering the questions as truthfully as possible. Your response will be highly confidential and will be used only for academic purpose.

For any questions pertaining to this study, please contact Addis Ababa Institute of Technology, School of Industrial and Mechanical Engineering.

Thank you in advance

Endale Alemayehu

Descriptive Note.

As it was indicated above, the aim of the study is to assess the service quality of EEU's and its improvement of service quality in comparison of In-house service delivery and outsourced service delivery. Here the researcher kept sets of criteria for weightage in comparison of each criteria, how important one from the other (degree of importance) for better service delivery by the organization.

This are the criteria for alternatives selection (In-house or outsourced service delivery).

1. Customer Service Responsiveness
2. Unplanned service outage (Reliability)
3. Safety (Human & Home appliance)
4. Employees Commitment

1. Deriving priorities (weight) for the criteria (Please put this (✓) mark under your choice)

S.no	Criteria	Which is Improtant (✓)	How Extent (Degree of Importance) (✓)				
			Equally Important (1)	Slightly Important (2)	Strongly Important (3)	Very Strongly Important (4)	Absolutely Important (5)
1	Customer Service Responsiveness						
	Unplanned Service Outage (Reliability)						
2	Customer Service Responsiveness						
	Safety (Human & home appliance)						
3	Customer Service Responsiveness						
	Employees commitment						
4	Unplanned Service Outage (Reliability)						
	Safety (Human & home appliance)						
5	Unplanned Service Outage (Reliability)						
	Employees commitment						
6	Safety (Human & home appliance)						
	Employees commitment						

2. Comparison (preference) of a tentative with degree of its preference from one to the other (in-house and outsourced service) at EEU operation for quality service deliver with respect to all criteria.

S.No	Criteria	Which alternatives are preferred? Put (√) on your choice		Degree of Preference Please put (√) on your choice				
				Equally Important (1)	Slightly Important (2)	Strongly Important (3)	Very Strongly Important (4)	Absolutely Important (5)
1	*With respect to customer service Responsivness*	*EEU In-house Service*						
		Out-Sourced EEU Service						
2	*With respect to unplanned service outage (Relaibility)*	*EEU In-house Service*						
		Out-Sourced EEU Service						
3	*With respect to Safety (Human & Home Appliance)*	*EEU In-house Service*						
		Out-Sourced EEU Service						
4	*With respect to employees Commitment*	*EEU In-house Service*						
		Out-Sourced EEU Service						

Questionnaire-2

Addis Ababa Institute of Technology

School of Graduate Studies

School of Mechanical and Industrial Engineering

Questionnaire on Selection of In-house & outsourced EEU's service for Quality Improvement

Part II

Interview Questions for EEU's management & employees staff

1. What does the existing EEU's service delivery look like?
2. Is the existing service delivery of EEU's satisfying your customers, in unplanned service outage, new power connection time & your employees in customer handling?
3. If no what will be the cause? And the company identified this cause and working towards this?
4. Explain about the existing human resource in performance, commitment and ethics at your company?
5. How do you evaluate the efficiency of responsiveness, service outage frequency & delay, & time for new power connection?
6. Does the organization measure the performance service efficiency? What are your KPI? What was the recent result?
7. How do you determine the customer service, unplanned outage frequency/delay and new power connection time in over all EEU service in respect of time, efficiency & ethics?
8. What is EEU's employee's competence? Customer handling? Training?
9. How EEU improve its service delivery? Especially in customer service, unplanned outage frequency/delay and new power connection? What you have done so far? Any written plan?
10. What is your experience in outsourcing of any service? And how was the feedback in service delivery level? Please give me brief explanation about some of your electrification project execution by outsourcing and its contractual issue? Additionally for lehulu, for bill collection and its contractual issues?
11. Do you expect outsourcing EEU's technical service to improve its existing service level? How?
12. Does the private sector has any role in EEU service delivery? In what scheme? Any practice in Ethiopia? Or neighboring country?

Questionnaire-2

Addis Ababa Institute of Technology
School of Graduate Studies
School of Mechanical and Industrial Engineering

Questionnaire on Selection of In-house & outsourced EEU's service for Quality Improvement

Part III

Interview Questions for Service quality (utility sectors especially) experts, funding organization like Africa development bank (ADB), World Bank, US aid etc.

1. Leaving aside the technological and financial constraints, How do you evaluate the existing service delivery of Ethiopian electric utility (EEU)?
2. How do you evaluate the responsiveness, electricity service outage frequency & delay, & time for new power connection? Is this task is needs core process to the organization?
3. In general, how the service delivery of electric utility will be affected by the employees of the utility company? How to make the effect positive?
4. Incentives and rewards will have any relation with utility service delivery?
5. What improvement strategy should EEU follow to improve the existing service? From neighboring or existing experience in Africa?
6. How do you think the private sector be involved in EEU's service delivery? In what schemes?
7. What will be the output of the service if EEU's agrees to outsource the technical service of its scope to private company in one wereda or kebele, or sub city?
8. What will be its political implication? And with employments issues? Any risk will appear?
9. How do you evaluate the technical service performance of private's service & public once? With respect to EEU's operation? In your organizational experience.
10. Has the concept of technical service (operation and maintenance) outsourcing in our country been practiced? In other sector like bank, insurance & factory maintenance? Not only low level operation like security, maintenance

Annex II Summary of Literature Review

S.No	Author	Title of Article	Country, year & Sector	Problem /purpose	Methodology	Result /Conclusion	My reflection on research gap
1	P. Ramseook-Munhurrun, S.D. Lukea-Bhiwajee, P. Naidoo	Service quality in the public service	Mauritius, 2010 (General)	To assess the extent to which service quality is delivered within the Mauritian public service by drawing on front-line employees (FLE) and customer perceptions of service quality.	SERVQUAL	Identify important areas for improvement in its service delivery. The findings revealed that employees and customers did not have significant differences in opinions in terms of the gaps between their perceptions and expectations of That public organization.	the study was limited to one public sector department, therefore the reliability of the results restrict the extent to which the findings Can be generalized across the Mauritian public service.
2	Gloria K.Q Agyapong	The Effect of Service Quality on Customer Satisfaction in the Utility Industry – A Case of Vodafone (Ghana)	Ghana, May 2011 (Telecom)	To examine the relationship between service quality and customer satisfaction in the utility industry (telecom) in Ghana	SERVQUAL model	The study documented that service quality is the Dominant route to customer satisfaction. identifying and satisfying customers' needs could improve network services because what is offered can be used to separate the company's own services from Competitors'.	For service quality improvement the study given that only skill should be improved to the company employees, No other strategy
3	Stilpon Neston & Ladan Mahoboobi	Privatization of Public Utility (the OECD Experience	Brazil, Rio April 1999 (Utilities)	Discussion on the development of the public policy debate on the ownership and control utility and the case of their privatization from different angle.	• Literature review & discussion • Case study of OECD	• Privatization has changed the enterprise (state owned utilities) involved with speed and depth never observed before • Access to international markets has created several global competitive companies out of previously inefficient state monopolies.	Try to show the positive impact of private sector, but only literature and past experience was discussed
4	Panu Poutvaara	Public Sector Out-sourcing	Germany, May 2014 (health service, Transportation, water and education)	The desirability of outsourcing provision of public service depends on their characteristics & market condition	Literature review and past data review	Out sourcing of public goods and service to private sector needs careful analysis to determine which activates would benefit from outsourcing and how outsourcing should be implemented	Still doesn't say weather outsourcing will have positive or negative impact on employment

5	A.A Congaray J.D.R Gois P.R.D Silva	Proposal for using AHP method to evaluate the quality of services provided by outsourced companies	Brazil, 2015	aims to describe the development stages of a decision support system for evaluating the quality of services Provided by outsourced companies that serve organizations in the Brazilian retail sector.	AHP multi-criteria	This research sought to evaluate the performance of outsourced services for furniture assembly provided to the company under study, using the AHP multi-criteria method. This model was specifically created for serving the retail organization, highlighting the importance of obtaining performance metrics of these services, thus Enabling an investigation of improvement opportunities for the company.	Limited to post outsourcing service evaluation using AHP,
6	George. O. Makowenga	Out sourcing and customer satisfaction in Kenya power Nairobi Region	Kenya, October 2013 (Power Sector)	To determine the relationship between contracted service and customer satisfaction	Descriptive analytical analysis (SPSS)	Adopted out sourcing in its strategies operation the respondent indicated that this lead to effectiveness and efficiency in service delivery, improved on the performance of the organization and a*** ineffective allocation of resource for improving the customer needs	Already they have assessed the experience with customer satisfaction. Nothing using from Engineering point of view.
7	Emmanuel O.Dyatoye Bilgis.B.Amole Sulaimon O.Adebiy	Patient's perception of quality service delivery of public hospitals in Nigeria using analytical hierarchical process	Nigerial Mach 2016 (medical)	To what extend do patients perception about health service quality at Nigeria public hospital	APH SERVQUAL	The most important factor to patients was the reliability (24%) & flowed by responsiveness (22%) , assurance (21%), feasibility (21%) and lest determinant factor is empathize dimension (11%)	Gap I observed, is that decision criteria is from SERVQUAL, not specific hospital operation, And also only it compared public hospitals not assessed private hospital.
8	Ligita Gasparenniene Jovita Vasuaskaite	Analysis of the criteria of outsourcing contract in public and private sector	Lativia April 2014	To analysis the criterion of outsourcing contrast in public & private sector	Review of the scientific literature	public sector's approach to outsourcing is prescribed by regulations while in private sector it is driven by the strategy, Criterion of making outsourcing contracts in both public and private sectors are similar, like list effectively, cost reeducation risk management, improvement of service quality, enhance customer satisfaction.	This study is lacks of specific sector(like water, telecom, electricity et..) And its methodology is only literature review.
9	L.N Fukey, S.S Issac, K.Balasubramaniam	Service Delivery Quality Improvement Models (Hotel)	India,2014	objective of this paper is to gravely evaluate various service delivery improvement models and identify hypothesis from the models to analyze whether these models are significant to hotel industry or not,	literature review	Find out the key elements to service delivery quality improvements are market and customer focus, motivated staff, understanding of concepts of service delivery and its factors etc.,.	mainly focused on hotel Industry. Also future research should concentrate on various other sectors given that the present study was used only In a particular sector.

10	Zue Mgweno	Assessment of effectiveness of outsourcing service in quality service delivery in public sector	Tanzania 2014 (public sector electric utility)	To assess the effectiveness of outsourcing service in quality service delivering public sectors	Qualitative and Quantitative	To a great extent outsourcing of service is beneficial to TANSECO in general specially in reduction of cost but in quality service delivery effectiveness the res** reveled some gap which need improvement and effort	The service type is only for construction and commissioning of the project. (medium voltage)
11	M.Bertolini M.Bevilacqua M.Braglia M.Frosolini	An analytical method for maintenance outsourcing service selection	Italy, 2004 (Construction)	dealing with the analysis of maintenance outsourcing by means of multi-criteria decision methods (MCDM) is reported	the analytic hierarchy process technique (AHP)	Maintenance outsourcing decision is analyzed in a different way, taking into account complex and extended sets of (tangible and/or intangible) strategic factors.	The proposed decision model of AHP is done on the case study of brick manufacturing sector, And it cannot be generalized with all industrial sector.
12	T.R. Annamalan A. Mahalingam A. Deep	Impact of private sector involvement on access and quality of service in electricity, telecom, and water supply sector	London Sept. 2013	To assess the impact of private sector participation (PSP) on access and quality in provision of electricity telecom and water service	By systematic literature review (Like Meta-regression analysis)	It was found that PSP did not have any significant impact on access and quality outcomes. Indicated that the effectiveness of PSP was limited in achieving improvement in access and quality. For electricity the evidence for positive outcomes was strongest for product & service quality. In telecom strongest is access.	The findings of this review do not constitute a comprehensive representation of the impact of PSP and pertain to only Access and quality outcomes.
13	Pierre-Olivier Pineau	Transparency in the Dark – An Assessment of the Cameroonian Electricity Sector Reform	Canada, August 12, 2004 (electricity)	To the understanding, assessment and analysis of privatization reforms	Case Study and Literature Review	Due to the weak institutions, competition and private ownership cannot be fully relied on, and that Government involvement is unavoidable.	First the contract is concession contract so it having investment from the ground no operation and maintenance.
14	R.Nepal J. Foster	Electricity Networks Privatization in Australia	Australia 2013 (Electricity)	To compare the economic performance between private and state owned electricity network in Australia	Comparative analysis and An overview of debate	Performance assessment suggested that privately own network has not been worse efficient than state owned in terms of the extent long term electricity price, falling network and operating cost, reduction in the duration and frequency of interruption and minimize on capitalization network.	My reflection on this article is, the methods is a simple comparative of state owned network and private owned network. It doesn't have a look about the state owned networks doesn't outsource of operation and maintenance of the electricity network. private owned means, private will invest on the

							network for long time of return on capital
15	A.N. Lochlainn M.L Collins	Outsourcing in the Public Sector	Ireland, Jan 2015 (General)	Examine the evidence of an out sourcing through the framework of value for money (VFM) in consideration of three main criteria (economy, efficiency and effectiveness)	A Value for Money perspective (VFM)	Highlights the complexity of decision making on outsourcing and argues that the merits of risks of outsourcing should be assessed in a compressive way. Finally the paper argues that the VFM methodology allows that the review to take a balanced approach to such assessment	There is no clear output on the result, it just left as it is a subjective matter and depend on actual situation from the given trends (experience)
16	Ligita Gaspareinen Rita Remeikane	Evaluation of the impact of outsourcing on the performance of Lithuania electricity.	Lithuania, 2016 (Electricity)	To evaluate the impact of outsourcing on the performance of Lithuania electricity industry.	Systematic analysis of the scientific literature and expert evaluation	The result on both the theoretical and empirical research shows that the most significant outsourcing determinants are identified in group of operational and strategically determinants. No negative outcomes of outsourcing application in the research	The scope of outsourcing extent is from generation, transmission and distribution to costumer.
17	Mark Velasquez and Patrick T. Hester	An Analysis of Multi-Criteria Decision Making Methods	USA, April 2013	examines the advantages and disadvantages of the identified methods	literature review	Explains how their common applications relate to their relative strengths and weaknesses and assess which advantages and disadvantages are more prevalent for each method.	It methodology is only literature review and on the practical (case study) it doesn't give any proof data.

Annex III AHP excel calculator template

AHP Analytic Hierarchy Process

bpmsg.com Multiple Input Summary Sheet

20 = k number of participants

4 = n number of criteria

Consolidated = Weighted geometric mean off participants

C **Consolidated**

	1	2	3	4	5	6	7	8	9	10
1		0.79	2.12	1	0	0	0	0	0	0
2	1.26		2.29	1.58	0	0	0	0	0	0
3	0.47	0.44		1.21	0	0	0	0	0	0
4	1	0.63	0.82		0	0	0	0	0	0
5	0	0	0	0		0	0	0	0	0
6	0	0	0	0	0		0	0	0	0
7	0	0	0	0	0	0		0	0	0
8	0	0	0	0	0	0	0		0	0
9	0	0	0	0	0	0	0	0		0
10	0	0	0	0	0	0	0	0	0	

1 Participant 1 — 1 — 1/0/1900

	1	2	3	4	5	6	7	8	9	10
1	1	3	9	5	0	0	0	0	0	0
2	1/3	1	7	9	0	0	0	0	0	0
3	1/9	1/7	1	9	0	0	0	0	0	0
4	1/5	1/9	1/9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

2 Participant 2 — 1 — 1/0/1900

	1	2	3	4	5	6	7	8	9	10
1	1	5	7	5	0	0	0	0	0	0
2	1/5	1	9	9	0	0	0	0	0	0
3	1/7	1/9	1	9	0	0	0	0	0	0
4	1/5	1/9	1/9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

3 Participant 3 — 1 — 1/0/1900

	1	2	3	4	5	6	7	8	9	10
1	1	5	5	9	0	0	0	0	0	0
2	1/5	1	7	5	0	0	0	0	0	0
3	1/5	1/7	1	9	0	0	0	0	0	0
4	1/9	1/5	1/9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

4 Participant 4 — 1 — 1/0/1900

	1	2	3	4	5	6	7	8	9	10
1	1	9	7	9	0	0	0	0	0	0
2	1/9	1	3	7	0	0	0	0	0	0
3	1/7	1/3	1	7	0	0	0	0	0	0
4	1/9	1/7	1/7	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

5 Participant 5 — 1 — 1/0/1900

	1	2	3	4	5	6	7	8	9	10
1	1	9	3	7	0	0	0	0	0	0
2	1/9	1	5	3	0	0	0	0	0	0
3	1/3	1/5	1	5	0	0	0	0	0	0
4	1/7	1/3	1/5	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

6	Participant 6								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	7	5	5	0	0	0	0	0	0
2	1/7	1	3	7	0	0	0	0	0	0
3	1/5	1/3	1	9	0	0	0	0	0	0
4	1/5	1/7	1/9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

7	Participant 7								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	5	1	7	0	0	0	0	0	0
2	1/5	1	5	9	0	0	0	0	0	0
3	1	1/5	1	3	0	0	0	0	0	0
4	1/7	1/9	1/3	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

8	Participant 8								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	7	5	3	0	0	0	0	0	0
2	1/7	1	9	5	0	0	0	0	0	0
3	1/5	1/9	1	7	0	0	0	0	0	0
4	1/3	1/5	1/7	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

9	Participant 9								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	1/7	9	5	0	0	0	0	0	0
2	7	1	9	7	0	0	0	0	0	0
3	1/9	1/9	1	7	0	0	0	0	0	0
4	1/5	1/7	1/7	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

10	Participant 10								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	1/3	9	3	0	0	0	0	0	0
2	3	1	7	9	0	0	0	0	0	0
3	1/9	1/7	1	9	0	0	0	0	0	0
4	1/3	1/9	1/9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

11	Participant 11								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	1/5	7	1/9	0	0	0	0	0	0
2	5	1	5	9	0	0	0	0	0	0
3	1/7	1/5	1	3	0	0	0	0	0	0
4	9	1/9	1/3	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

12	Participant 12								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	1/5	5	1/7	0	0	0	0	0	0
2	5	1	7	5	0	0	0	0	0	0
3	1/5	1/7	1	1/5	0	0	0	0	0	0
4	7	1/5	5	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

13	Participant 13								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	1/9	7	1/7	0	0	0	0	0	0
2	9	1	9	1/5	0	0	0	0	0	0
3	1/7	1/9	1	1/7	0	0	0	0	0	0
4	7	5	7	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

14	Participant 14								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	1/9	3	1/5	0	0	0	0	0	0
2	9	1	7	1/9	0	0	0	0	0	0
3	1/3	1/7	1	1/7	0	0	0	0	0	0
4	5	9	7	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

15	Participant 15								1	1/0/1900
	1	2	3	4	5	6	7	8	9	10
1	1	1/7	5	1/3	0	0	0	0	0	0
2	7	1	1/5	1/7	0	0	0	0	0	0
3	1/5	5	1	1/9	0	0	0	0	0	0
4	3	7	9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

16	Participant 16						1		1/0/1900	
	1	2	3	4	5	6	7	8	9	10
1	1	1/5	1/5	1/9	0	0	0	0	0	0
2	5	1	1/3	1/5	0	0	0	0	0	0
3	5	3	1	1/3	0	0	0	0	0	0
4	9	5	3	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

17	Participant 17						1		1/0/1900	
	1	2	3	4	5	6	7	8	9	10
1	1	1/7	1/7	1/3	0	0	0	0	0	0
2	7	1	1/5	1/3	0	0	0	0	0	0
3	7	5	1	1/5	0	0	0	0	0	0
4	3	3	5	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

18	Participant 18						1		1/0/1900	
	1	2	3	4	5	6	7	8	9	10
1	1	1/3	1/5	1/5	0	0	0	0	0	0
2	3	1	1/7	1/5	0	0	0	0	0	0
3	5	7	1	1/7	0	0	0	0	0	0
4	5	5	7	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

19	Participant 19						1		1/0/1900	
	1	2	3	4	5	6	7	8	9	10
1	1	1/5	1/9	1/5	0	0	0	0	0	0
2	5	1	1/3	1/5	0	0	0	0	0	0
3	9	3	1	1/9	0	0	0	0	0	0
4	5	5	9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

20	Participant 20						1		1/0/1900	
	1	2	3	4	5	6	7	8	9	10
1	1	1	1/9	1/5	0	0	0	0	0	0
2	1	1	1/5	1/7	0	0	0	0	0	0
3	9	5	1	1/9	0	0	0	0	0	0
4	5	7	9	1	0	0	0	0	0	0
5	0	0	0	0	1	0	0	0	0	0
6	0	0	0	0	0	1	0	0	0	0
7	0	0	0	0	0	0	1	0	0	0
8	0	0	0	0	0	0	0	1	0	0
9	0	0	0	0	0	0	0	0	1	0
10	0	0	0	0	0	0	0	0	0	1

AHP Analytic Hierarchy Process (EVM multiple inputs)

K. D. Goepel Version 11.10.2017 | Free web based AHP software on: http://bpmsg.com

Only input data in the light green fields and worksheets!

n=	4	Number of criteria (2 to 10)	Scale:	1	AHP 1-9
N=	20	Number of Participants (1 to 20)	α:	0.1	Consensus: 35.2%
p=	0	selected Participant (0=consol.)	2	7	Consolidated

Objective Better Service Delivery at EEU

Author Endale

Date May 13/2018 Thresh: 1E-07 Iterations: 6 EVM check: 2.2E-08

Table

	Criterion	Comment	Weights	Rk
1	Criterion 1	Customer Service Responsiveness	27.5%	2
2	Criterion 2	Unplanned Service Outage (Reliability)	34.6%	1
3	Criterion 3	Safety (Human & home appliance)	17.2%	4
4	Criterion 4	Employees commitment	20.6%	3
5	Criterion 5		0.0%	
6	Criterion 6		0.0%	
7	Criterion 7		0.0%	
8	Criterion 8		0.0%	
9		for 9&10 unprotect the input sheets and expand the	0.0%	
10		question section ("+" in row 66)	0.0%	

Result

Eigenvalue lambda: 4.082

Consistency Ratio 0.37 GCI: 0.11 CR: 3.0%

Matrix

	1 Criterion 1	2 Criterion 2	3 Criterion 3	4 Criterion 4	5 Criterion 5	6 Criterion 6	7 Criterion 7	8 Criterion 8	9 0	10 0	normalized principal Eigenvector
1 Criterion 1	-	4/5	2 1/8	1	-	-	-	-	-	-	27.48%
2 Criterion 2	1 1/4	-	2 2/7	1 4/7	-	-	-	-	-	-	34.63%
3 Criterion 3	1/2	3/7	-	1 2/9	-	-	-	-	-	-	17.24%
4 Criterion 4	1	5/8	5/6	-	-	-	-	-	-	-	20.64%
5 Criterion 5	-	-	-	-	-	-	-	-	-	-	0.00%
6 Criterion 6	-	-	-	-	-	-	-	-	-	-	0.00%
7 Criterion 7	-	-	-	-	-	-	-	-	-	-	0.00%
8 Criterion 8	-	-	-	-	-	-	-	-	-	-	0.00%
9 0	-	-	-	-	-	-	-	-	-	-	0.00%
10 0	-	-	-	-	-	-	-	-	-	-	0.00%