ASSESSMENT OF CHALLENGES AND OPPORTUNITIES OF ELECTRIC POWER AND TELECOMMUNICATION NETWORK INFRASTRUCTURE (*A CASE STUDY OF ADIGRAT TOWN*)

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Abstract: The purpose of this study was to investigate the challenges and opportunities of electric power and telecommunication infrastructure in Adigrat town to create a comprehensive strategy which is crucial to improve the access and quality of the infrastructure in this area. A mixed research method i.e. qualitative and quantitative research approach was used to carry out the research analysis and interpretation over the primary and secondary data collected from the study area.

The research analysis made known that the substation feeding the town has two transformers with capacity of 15KV(kilo volt), 20MVA (Mega Volt Ampere) and 33KV, 9.6 MVA which could provide substantial access to the whole town and peripherals whereas the level of electricity access in Adigrat town was not adequate i.e. from the survey made about 25.44% of the households have no standard access of electricity and 75.5% of the streets found in the town have no street lights where the municipality should provide an absolute concern. As per the observation made in selected sites of the town the electric power system infrastructure was very old which needs intensive maintenance and upgrade. Besides of having limited access the existing electric power infrastructure was found highly affected due to the existing man power, transport facility, tools, machineries and material was not adequate, high power interruption, unbalanced power distribution system, estimated billing issues, lack of integrated master plan and very old electric power network where this deserves high priority.

Customers have good access to Ethio-telecom infrastructure especially full wireless infrastructure access and 74% of wired infrastructure i.e. broadband and public switching line. The infrastructure width in most of the roads was too small and not enough for Ethio-telecom's and Ethiopian Electric Utility's cable, equipment, pole erection and installation. Even though the Ethio-telecom's infrastructure has broad future extension capacity to cover the town with slight expansion its plan was not integrated with the town's master plan. This study has confirmed the major challenges of electric power and telecommunication infrastructure in the town were lack of integrated master plan, limited electric power, limited wired telecommunication infrastructure, below standard infrastructure space and frequent power interruption. The Electric and telecommunication infrastructure in the town was built based on future load forecasting strategy with multiple choices.

Key words: Electric power distribution network, Infrastructure, Telecommunication network, Broadband, mobile network, voltage drop, unbalanced power

1. Introduction

1.1. Background

Infrastructure includes the fundamental facilities and systems serving a country, city, or other area, including the services and facilities necessary for its economy to function. Infrastructure is composed of

public and private physical improvements such as roads, bridges, tunnels, water supply, sewers, electric grids and telecommunications.[1]

Electric grids include power generation, transmission and distribution systems. Electric power distribution is a final stage in delivery of electric power where it carries electricity from the transmission system to individual customers in towns and rural areas. Distribution substations connect to the transmission system and lower the transmission voltage to medium voltage ranging between 2 kV and 35 kV with the use of transformers. Primary distribution lines carry this medium voltage power to distribution transformers located near customer's premises. Distribution transformers again lower the voltage to the utilization voltage used by lighting, industrial equipment or household appliances.[2]

Telecommunication is the transmission of signs, signals, messages, words, writings, images and sounds or information of any nature by wire, radio, optical or electromagnetic systems.[3,4]

It is believed that a town should have well established infrastructure which takes in to account its future demand and provides quality service to the society living inside. Electric power and telecommunication infrastructures are among the primary pillars for sustainable development in a nation particularly in a town.

As per the preliminary survey made earlier Adigrat town was facing a number of challenges in this regard i.e. the current electric power distribution network within the town is not adequate and reliable enough to provide the required service to all the residents and it is characterized by frequent electric power interruption. The wired telecommunication infrastructure was also found limited in terms of access but the wireless infrastructure was comprehensive enough in terms of quality and coverage. In addition to this the infrastructure area left for installing electric power and telecommunication equippments and devices is not enough which in turn is creating additional problems like extending power lines over buildings because of not having enough space, collision of vehicles with electric or telecommunication poles ,electric transformers and communication switching devices. The infrastructure area left in two sides of most of the roads in the town was found too small and not enough to install electric power cables, telecommunication fiber optic and coaxial cables and to erect mounting poles which was critical problem hindering reliable infrastructure development. So this study is expected to investigate the existing problems and opportunities using appropriate techniques and provide comprehensive strategic solution to the existing problems.

1.2. Statement of the problem

Adigrat town has currently a population of 98,000 and having total households of 18,000 where the access of electricity within the town was found very limited and it is characterized by frequent electric power interruptions. The wireless telecommunication infrastructure built in the town was found reliable except a onetime shot off during power interruption until a stand by generator starts. Whereas the wired telecommunication infrastructure was found inadequate and did not cover 45% of the town spatial area. The socio-economic activity of the town was found highly affected due to this consequence. Therefore this study was conducted to assess the challenges and opportunities of the electric power and telecommunication infrastructure in the town focusing on the following questions.

I. What is the status of electric power and telecommunication infrastructure access and quality in the town?
II. What are the basic challenges of electric power and telecommunication infrastructure in the town?
III. What are the existing opportunities related to electric power and telecommunication infrastructure to enhance and scale up for the future in order to improve services?
IV. What kind of infrastructure planning strategy was used?

1.3. Objective

1.3.1. General objective

The general objective of this study was to assess the challenges and opportunities of electric power and telecommunication network infrastructure and to provide strategic solution for the challenges.

1.3.2. Specific objectives

The specific objectives of this study were

- To assess the status of electric power and telecommunication infrastructure access and quality in the town
- To identify the basic challenges of electric power and telecommunication infrastructure
- To identify the existing opportunities related to electric power and telecommunication

infrastructure for enhancing and scale up purpose in the future

- To create a comprehensive strategy for the challenges related to electric power and Telecommunication infrastructure and
- Propose a robust electric power and telecommunication infrastructure's planning strategy.

1.4. Description of study area

This study was conducted in Adigrat town where Adigrat is a city and separate woreda in the Tigray Regional State of Ethiopia. It is located in the Misraqawi Zone at longitude and latitude 14°16′N 39°27′E, with an elevation of 2,457 metres (8,061 ft) above sea level and below a high ridge to the west. Adigrat is the last important Ethiopian city south of the border with Eritrea, and is considered to be a strategically important gateway to Eritrea and the Red Sea. Adigrat was part of Ganta Afeshumworeda before a separate woreda was created for the city. Currently, Adigrat serves as the capital of the Eastern Tigray zone. The reason for the selecting Adigrat town as a study area was due to the high population existing in the town next to Mekelle and the town has limited electric power and telecommunication infrastructure where it is suffering from frequent power interruption and limited wired telecommunication network access as observed during the preliminary assessment made earlier.

2. Research method and materials

2.1. Materials

Clamp meter was used to measure high tension and low tension current in different areas of the town to create a correlation with the electric loads available in households, business centers and industries. DT9205M digital multi-meter was used to measure the existing voltage and power rating of the high and low tension lines to determine voltage drops and whether power entering to each customer is within standard range. To measure vertical distance between high tension or low tension electric power lines and ground, and size of infrastructure area meter was used to determine whether the vertical height was appropriate and the infrastructure area was sufficient enough.

2.2. Research Methods

2.2.1. Research design

Qualitative and quantitative approach was used as research method as this method was so helpful to get detail data from many participants and to apply document review method to validate and determine facts.

2.2.1.1. Sources of data

The primary data source was collected from households, business centers, industries, Ethiopian Electric Utility office Adigrat branch, Ethio-Telecom Adigrat branch and Adigrat municipality office whereas secondary data source of this study was gathered from the recorded documents found in Ethiopian Electric Utility office Adigrat branch, Ethio-Telecom Adigrat branch and Adigrat municipality office with primary focus given to infrastructure access, quality, challenges and opportunities and planning strategy.

2.2.1.2. The samples and sampling techniques

In this research simple random sampling was used as a sampling technique in order to include all respondents with equal chance and get a representative data at full picture. Since the research considers different participant groups i.e. sample was selected based on characteristics of population and objective of study the sample size taken from each group is summarized in the table below as per the standard sample size range is from 10%-40% of the target population.

Table 1: sample size versus population considered

S.no	Group	Population/Quantity	Sample size	Remark
1	Households and business centers	18,000	1800	10% of total
2	Adigrat Ethiopian Electric Utility	27	12	44.44% of total
3	Adigrat Ethio-Telecom	20	9	45% of total

4	Adigrat Municipality office	20	10	50% of total

2.2.1.3. Instruments and procedure of data collection

Closed and open ended questionnaires, interview, observation and document review were used as data collection tools. The observation was made to strengthen the questionnaire and interview responses. The interview responses were recorded using field notes. Observation was very important to take some field observations and results about electric power and telecommunication infrastructures' maintenance quality, installation and erection process, scope of infrastructure access, service quality and challenges and opportunities of the infrastructure established within the town. The document review was used to analyze data records and documents to sufficiently support and validate against the primary data.

2.3. Data analysis method

The data collected was analyzed using both qualitative and quantitative method/mixed approach/ of the data analysis technique. Depending on the nature of collected data through questionnaire, interview and observation different statistical techniques were employed in this study. These data were coded, organized, analyzed and interpreted both qualitatively and quantitatively.

To analyze the quantitative data percentage, frequency and mean value methods were used. These statistical tests were used for the purpose of testing different variables between the respondent groups. Besides of the statistical process on the quantitative data the qualitative data was narrated qualitatively using words, phrases, statements and paragraphs obtained from interviews, open and close ended questions and observation. Hence the qualitative data was used as the complement of quantitative data.

3. Result and discussion

3.1. Results

Adigrat town was facing a lot of problems related to the electric power and telecommunication infrastructure. To remedy this problem primary and secondary data was collected through different kinds of data collection tools i.e. questionnaires, interview and observation and recorded documents.

The results/findings generated using the quantitative and qualitative method are shown below

Table 2.0: Access of Electricity at town level (households and business centers)

Access of Electricity for households and business centers	
Measurement parameter	Survey result (%)
Customers who have private kilo watt hour meter (KWHM)	74.56
Customers who get access from neighbor KWHM	6.5
Customers who have common KWHM	14.94
Customers who have no access	4
Total	100

Table 3: Access of Electricity at Kebelle level in Adigrat town

S. No	Kebelle	self owned KWHM	Access from neighbor KWHM	Common KWHM	No access
		%	%	%	%
1	01	18.48	18.80	7.06	15.28

2	02	18.70	11.11	11.15	8.33
3	03	20.19	7.69	5.20	8.33
4	04	13.64	21.37	30.86	12.50
5	05	16.02	7.69	24.91	12.50
6	06	12.97	33.33	20.82	43.06
Total		100	100	100	100

Table 4: Monthly bill issuing and KWHM reading system availability at town level

Bill issuing (Monthly KWHM reading)	
Measurement parameter	Survey result (%)
Reading service is regularly available	82.47
Reading service not periodical	17.53
Total	100

Table 5: Monthly bill issuing and KWHM reading system availability at Kebelle level within the town

S.No	Kebelle	Reading service is regularly available	Reading service not periodical	remark
		%	%	conversion
1	01	17.89	11.22	11.22% of (17.53%) is 1.97 %
2	02	18.95	7.92	
3	03	18.18	10.23	
4	04	16.56	17.49	
5	05	13.54	27.06	
6	06	14.88	26.07	
Total		100	100	

Table 6: Service quality of Ethiopian Electric Utility office (Adigrat branch)

Service quality provided by EEU(Adigrat branch)	
Measurement parameter	Survey result (%)
Low	62.00
Moderate	30.78
Good	7.22
Total	100

Table 7.0: Street lighting availability at town level

Street Lighting availability	
Measurement parameter	Survey result (%)
Street Light is available in the street around residence	24.5
Street Light is not available around our residence	75.5
Total	100

Table 8: Data summary on availability of street lighting at Kebelle level

S.No	Kebelle	Street light is available in the area of residence (%)	Street light is not available in the area of residence (%)
1	01	14.74	17.29
2	02	26.98	13.32
3	03	17.23	16.48
4	04	14.51	17.37
5	05	12.24	18.10
6	06	14.29	17.44
Total		100	100

Table 9: Some EEU specific standards versus existing status (through observation)

S.No	Name of standard (standard item)	Standard description	Existing Condition (from survey)
1	High tension elevation from ground	9-12 meters	As required (9-12 m)
2	Low tension elevation	6-8 meters	As required (6-8 meter)
3	Distance of electric pole from building	1.5 meter	On average less than 1 meter
4	Distance of electric pole from road	1.5 meter	On average less than 1 meter
5	Distance of electric transformer from building	3 meter	On average less than 1 meter
6	Distance of electric transformer from road	3 meter	On average less than 1 meter
7	Transformer span (3-ϕ)	350 meter radius	It goes above 500 meters
8	Street lighting power line length	<= 500m	Above this

Table 10: Telecommunication infrastructure access in Adigrat town

S.No	Measurement parameter/variable	Survey result (%)	
		Available in the area /location	Not available in the area/location
1	Mobile network access	100	0
2	Broadband network access	31	69
3	Wired /wireless public telephone network access	74	26

4	MSAG is available in your residence/work area at a distance of less than 500 meter	8	92
5	Any technology for wireless internet access in areas where base station is available but fiber optic and MASG is absent	0	100

Table 11: Ethio-Telecom's service quality at Adigrat town

S.No	Measurement parameter/variable	Survey result (%)		
		Poor	Satisfactory	Too standard
1	Mobile network quality (good sound quality, less distortion and fast wireless internet service)	2	21	77
2	Broadband internet speed (above 18MBS)	22.5	12	65.5
3	Fast maintenance service (within 30 minutes duration) available	5	26.8	68.2
4	Telecommunication network service (maximum two interruptions within three days is Ethio-Telecom standard)	12	6	82

3.2. Discussion

3.2.1. EEU services & Electric power infrastructure

As it shown in table 2 above the level of electricity access in Adigrat town was not adequate i.e. from the survey made about 4% of the households have no access of electricity, 6.5% of the households have electric access extended from their neighbors, 14.94% have common KWHM and 74.56% of them have their own KWHM. Even though about 21.444% of the households included in the survey were getting electricity access from neighbor households and using common KWHM the access level was found very limited due to long distance between households where electric current carrying lines faces large resistance and large queue (turn by turn) in case of common KWHM electric access if the device in use requires above 20 ampere current. The secondary data collected from EEU shows 2723 households are waiting to get KWHM where electric power distribution network was not installed around the households. When we compare with the total population of the town in household level still significant amount of households are not having electric power access. In addition to the 2723 households another 70 households are also requesting EEU to provide them standard KWHMs because currently they are using KWHMs with current rating of 10A which is only used for lighting purpose. From the interview made with the EEU technical staff which was proved further through observation the 2723 households were in the waiting queue due to the reason that there was no enough electric power distribution materials and adequate manpower in the office. Until January 2018 the total customers' of EEU in Adigrat town were 11,335 where among this 9261 were households, 2011 business centers and 63 industries.[5]

Peripheral areas around Adigrat town like Genahti, Betmaria, Buket, Maybaea, Sasun, Kendaero and Golea have no access of electricity. The people living in these areas were asking EEU Adigrat district to get access of electricity but the residents were requested to pay the cost of the infrastructure first and wait until necessary electric materials would be available. The town municipality could not cover the infrastructure cost for the peripheral areas due to budget limitation. The people living in the mentioned areas are facing health problems because they are using kerosene gas for lighting purpose and financial crisis due to high expense for wood and kerosene gas used as a fuel for food preparation and lighting purpose.

Table 12: Customers of Ethiopian Electric Utility in Adigrat town

S.No	Type of customer	Unit	Total customers
1	Domestic customers (households)	number	9261
2	General customers (Business related)	number	2011
3	Industries	number	63
Total			11335

Source: EEU Adigrat District customer record office

Table 13: Price per KW for domestic, General (commercial) and Industries as per the EEU rate

No.	KW range	Price per KW within range	KWH Meter rent cost(birr)/ 1-ϕ KWHM	Customer Type
1	1-50 KW	0.2730 cents/KW	3.4	Domestic
2	51-100 KW	0.3564 cents/KW	6.82	
3	101-200 KW	0.4993 cents/KW	10.24	
4	201-300 KW	0.5500 cents/KW	10.24	
5	301-400 KW	0.5666 cents/KW	10.24	
6	401-500 KW	0.5880 cents/KW	10.24	
7	>500 KW	0.6943 cents/KW	13.65	
8	1-50 KW	0.6088 cents/KW	14.49	General (Commercial)
9	>50 KW	0.6943 cents/KW	22.56 (3-ϕ KWHM)	
10	High power	Active reactive depends on power factor	53.57 (3-ϕ KWHM)	Industries

Source: EEU Adigrat District energy sales operation office records

As per the data collected from households and business centers through questionnaire and interview shown in table 6 above 62% of the respondents rated that the quality of service of EEU Adigrat district was unsatisfactory. The data collected through interview and questionnaire from EEU technical staff with full consensus also confirmed that there was on average 3-5 times a day power interruption and KWHM reading service is not inclusive to all households due to shortage of technical staff which in turn incurs additional costs on customers. For example, if the first month's energy consumption reading in a particular KWHM is 55kwh (kilo watt hour) and assume this monthly energy consumption rate is the same for the next eight months where payment in each month was 2 birr i.e. the KWHM rent only excluding consumption payment due to the reason the consumption rate was not read by the experts and at the eighth month when the expert read the total energy consumption it is 440 kwh. Now if it is to be calculated per month the customer should pay 26.42 birr and in eight months 211.38 birr whereas if the payment is done after eight months due to lack of energy consumption reading service the payment requested from this customer for using 440 kwh is 268.96 birr where the difference 57.58 birr is overhead cost this customer is obliged to pay without using any additional energy rather due to the fault of the EEU office for not giving the reading service monthly. This phenomenon was creating a negative impact in the economy of the country due to the reason the payment was not collected on time to build additional infrastructure and it incurs additional payment on customers due to the delayed energy consumption reading service.

As indicated in table 4 above 82.47% of the households included in the survey asserted that KWHM reading service was offered on monthly. But one KWHM reader is expected to read about 2500 households energy consumption and this number is huge enough which could not be covered by a single reader. Since the billing system is centralized it is difficult to consider complaints from customers on time but if the complaint is evidence based the clerk office could solve it internally.

As per the observation made in selected sites of the town the electric power system infrastructure was very old which needs intensive maintenance and upgrade. Relating the feedback of the households, EEU technical staff and observation made the service quality of EEU was very limited due to the existing man

power and material was not adequate, 3-5 times a day power interruption, unbalanced power distribution system, estimated billing issues for about 17.53% of households and very old electric power network where this deserves high priority. In addition to this the service quality of EEU was constrained by shortage of transport facility, tools and machineries. In the case of machineries lifting, drilling, crane, wire and cable strainer (to firm and project AAC in transmission and distribution) are expected to be available in the district but totally missed. The EEU Adigrat district has no standard tools like well insulated screw drivers, cutters, drillers, cable stripper, welding and devices like high current clamp meters, insulation testers and leakage current testers. Safety materials like hand gloves, insulated dress and high insulation shoes are also not available in the district. Material shortage is also another constraint and the materials most often missed are transformer, Aluminum Alloy cable (AAC), High tension hook, drop out fuse, lighting arrester (for thunder protection), low voltage hook, ceramic insulator, high current rate (HRC) fuse for transformers and pillar accessories for 315KVA and above transformer.

Adigrat town was suffering from frequent power interruption due to the power distribution network was very old, highly overloaded and unbalanced power distribution lines carrying different loads, no protection devices were installed at appropriate locations. The power distribution network was very old which was installed and erected since 1998's when the city was using generator and currently the wooden electric poles are failing down due to wind and wood decaying problems, the AAC cables are not also fixed tight and characterized by frequent drop down due to hook drop down and cut at the damaged points. The power distribution network was not equipped with protection devices to isolate recommended areas when a short circuit occurred at high tension lines at a specific location the whole town connected to the feeder lines coming from substation becomes interrupted. But if protection devices like relay based contactors and circuit breakers could be installed at appropriate locations any short circuit occurred at any location of the high tension lines can affect that particular location only. So this could solve power interruption problems caused due to short circuit on the high tension lines i.e. if a particular location is affected due to high tension short circuit only that particular location could be interrupted but not the whole town because this particular location is isolated by the protection devices.

Since the electric load at each household level and commercial business centers was not studied well and if any request from customers addressed to the EEU branch the technicians simply extend power line from the low tension line without load consideration. This trend created one line to be overloaded and another line to be under loaded in the three phase system which in turn creates low and high power situation in the town or commonly called unbalanced power situation.

The transformers erected at the town were found highly overloaded due to the coverage was above 500 meter where the standard was 350 meter and it carried high load i.e. above its rating. This cause leads to unbalanced power due to voltage drop and resulted in repeated power interruption problem. The case why transformers are overloaded is due to shortage of transformer availability in the town and there is no choice to stop the society request waiting for the transformer to be available.

Validating the data collected through questionnaire and interview from EEU technical staff the root causes of power interruption problem were short circuit occurred due to wind, trees, rain and vehicle collision with electric pole, transformer and due to overloaded power distribution system.

Electric power interruption was a common problem in the whole town because two feeder lines were feeding the town without protection devices. Households, hotels, restaurants, maintenance centers, metal and wood workshops, construction firms, banks, Ethio-telecom, Adigrat University, different colleges, hospital, Internet centers, milling machines and industries except APF were highly affected due to frequent power interruption problem. Particularly micro and small enterprises could not withstand this problem since most of them were working in a rented building and credit given from microfinance. This situation has created interrupted work environment, high delay over contracts and profitless work as a consequence.

Street lighting has a potential advantage during night time to provide lighting and encourage the town's society to build strong market which can be operational during day time and night and to avoid crimes allowing free movement of the people. Even though straight lights were available in some main roads' of the town most of the road networks lack this opportunity. The existing street lights were not working properly that is some of the street lights On during day time and Off during night time due to wrong timer setting and others off permanently due to manual operation where the operator could not On and Off timely

being once Off. As observed from the survey made the street lighting access in Adigrat town was very limited. The town municipality argues this limited access was due to budget constraint. But as compared to other projects the annual budget allocation to this infrastructure was small enough which could not address the need of the society.

From the observation made the distribution of street lighting in the town was found unfair and it was condensed at the center of the town and main roads. At Kebelle 01 areas around Mtsaewerki, Edagabearay, Endabuzu and Hadush mender, at kebelle 02 areas around Hadush adi, Endabagobez and Cheanadug , at kebelle 03 Meida Agame , at kebelle 04 except areas around Yemene Gebremeskel KG, Meida Agame main street and main street to University in both gate ways, Kebelle 05 areas around Giorgis church, newmillennium college, Funete Birhane primary and secondary school, Wereda Administration and Golgota Medhanealem church and Kebelle 06 areas around Bet-Hntset, Meneharia, seed cultivation project area and Cherkos church were not having sufficient street light access. The society in the town was affected at large due to this limited access. Due to some crimes occurred in the town during night time in areas which do not have street light access the residents fear from this attack and movement in those places during night time is very limited as a consequence.

As shown in table7 above 75.5% of households replied that there was no street lighting in their area of residence and all respondents from EEU and Adigrat town municipality bureau declared that street lighting was available in the areas of main roads which by itself lacks periodical maintenance; on average maintenance was made after four months due to lack of maintenance system. As per the response of all EEU technical staff and observation made the illumination power and contrast of the existing street lights was convenient to human eye. Triangulating this street lighting access in the town was found very limited, even for the existing its maintenance was poor and it was one of the leading infrastructure problems in Adigrat town.

Table 14: Street lighting data

No.	Data item	Unit	Quantity		Remark
			Number	%	
1	Incandescent lamp	pcs	313	10.82	Total street light length 109.5 KM
2	Florescent lamp	pcs	963	33.30	
3	Sodium lamp	pcs	1616	55.88	
Total			2892	100	

Source: EEU sales operation office

All the EEU technical staff replied that a number of collisions between electric pole and vehicle, vehicle and transformer have occurred in the town due to infrastructure width i.e. distance between building and road was not too standard that was below 1.0 meter on average where electric poles, high and low tension over head cables and transformers were installed. The data collected from EEU documents shown that from 2012 onwards over 23 collisions [6] i.e. between vehicle and electric pole, vehicle and transformer have occurred. As indicated in the documents the primary reason for the occurrence of the collision was due to small infrastructure area on average less than 1.0 meter width from the road end to building. Analyzing this fact the major problem causing collision was narrow infrastructure area and the EEU transformers, electric poles carrying high tension and low tension lines were not installed at an appropriate distance from main road.

All the respondents from EEU and the town municipality bureau confirmed that there was no synchronized and integrated excavation work for erection and installation purpose of electric poles, underground electric cables and fiber optic lines done by Ethiopian Electric Utility and Ethiopian Telecommunication Corporation in the town which was creating destruction of property of the respective offices as assured due to observation made. On top of this the respondents asserted that the problem was happening due to lack of coordination center in the town to facilitate integrated infrastructure expansion.

From the measurement based observation made the current electric power network installation includes future demand to support about 35,000 households but it needs an upgrade in the low tension lines and

transformers in the town. The substation feeder lines running to the town were also placed at appropriate distance and carrying the 33 KV, 9.6MVA and 15 KV, 20MVA but the electric power network in the town is very old which lack protection devices in the power distribution networks to protect surge currents and unneeded power interruptions in the town.

Table 15: High tension and low tension data

S.No	Data item	Unit	Quantity	remark
1	15 KV line	Kilo meter	202.2KM	AAC used 50 mm^2 and in peripheral areas 19.83 KM span
2	Low tension power network (1-ϕ)	KM	36.25	AAC used 25 mm^2 and 50 mm^2
3	Low tension power network (2-ϕ)	KM	8	AAC used 50 mm^2
4	Current total power demand	KVA	31,985	This covers in town and outside town
5	Total Number of transformer	number	203	Different capacity

Source: EEU sales operation report September 2017E.C

As per the observation made and the EEU staff replied in the questionnaire and interview there was no detail neighborhood and master plans for electric power distribution networks in the town. This was a critical problem because the high tension and low tension electric power network location and capacity was not known a head for planning purpose simply the technicians extend power line to customers without knowing whether the system is overloaded or under loaded. The respondents also indicated the major causes of electric hazards in the town were electric power lines contact with buildings, short circuit, vehicle collision with electric pole, and power cable drop down from pole.

It is known that EEU is replacing wood electric poles by concrete poles in different areas of our country. As per the response given from EEU Adigrat branch office and EEU Semen Region office Mekelle and stated in the document of Ethiopia-additional financing for energy access project[7]; Adigrat town is included in this package which helps to have well insulated, balanced and low interruption electric power network and concrete pole which could alleviate pole fail down problem.

3.2.2. Ethio-Telecom services & Telecommunication infrastructure

77.78% of the respondents from Ethio-telecom technical staff replied that the telecommunication switching device (multi service access gate-MSAG) and poles carrying fiber optic lines and copper cable were not installed at an appropriate distance from main road. As per the observation made also MSAG, poles carrying fiber optic lines and Copper cables were not erected and installed at a standard distance from the main road and building. It was on average about less than one meter from main road but the standard infrastructure width should be 3 meters. As it was referred from the documents of Ethio-telecom Adigrat branch 2 collisions between vehicle and MSAG, 8 collisions between vehicle and Ethio-telecom pole have occurred which was a potential reason for service failure. Scrutinizing this phenomena the infrastructure width in most of the roads was too small and not enough for Ethio-telecom Equipment and pole erection and installation.

82% of the respondents from Ethio-telecom Adigrat branch, Adigrat town municipality and households considered in this survey agreed that the service quality of Ethio-telecom was good enough to support the needs of the society in the town. They also asserted that customers have good access to Ethio-telecom infrastructure especially full wireless infrastructure access and 74% of wired infrastructure.

It is believed that any kind of infrastructure should include future demand to address the need of society within the town and in its peripheral area in the future time. Ethio-telecom was building strong infrastructure in towns and villages by now to provide inclusive service. To examine this questionnaire and interview based survey was made in Adigrat town focusing Ethio-telecom technical staff as respondents.

From the observation made on Ethio-telecom infrastructure in the town the researcher understood the current telecommunication network installation includes future demand i.e. at the main roads fiber optic cable was installed and it was with large capacity (core-48) to provide service for more than 20,000 households who can use public phone, 200,000 internet users and over 140,000 mobile users but it needs expansion to cover the peripheral areas and to customers with no access installing additional MSAGs. From the observation made also the existing telecommunication network was expandable only it needs additional fiber optic extension, base station and MSAGs to cover peripheral areas. Ethio-telecom was using a technology to provide network access to customers out of network range through professional telecommunication services (PTS) but it is expensive. Therefore any lodge or recreation centers out of network access could use this opportunity.

Table 16: Customers of Ethio-telecom and service type

S.No	Customers	Service type	Customer type
1	Air force near Agamos Hotel	>3MB broad band access	Critical
2	Poly technic	>3MB broad band access	Critical
4	Catholic Church	>3MB broad band access	Critical
5	Adigrat University	>3MB broad band access	Critical
6	ERA	>3MB broad band access	Critical
7	EEU	>3MB broad band access	Critical
8	Hospital	>3MB broad band access	Critical
9	Finance	>3MB broad band access	Critical
10	Wereda administration	>3MB broad band access	Critical
11	APF	>3MB broad band access	Critical
12	Agamos Hotel	>3MB broad band access	Critical
13	Social Affairs office	>3MB broad band access	Critical
14	Commercial and Wegagen banks	>3MB broad band access	Critical
15	Non critical customers (<3MB)	All other banks and business centers	Non critical

Source: Ethio telecom critical customer list August, 2017

Ethio-telecom Adigrat branch has a standard and detail neighborhood and master plan of telecommunication networks within the town but it was not integrated to the town master plan. Every system maintenance was done based on the map tracing the location of the household location, fiber optic, base station and MSAG. This was confirmed through observation made on the office and infrastructure sites.

Table 17: Fiber optic, base station and MSAG data

No.	Data item	Unit	Quantity	remark
1	MSAG	number	14	Located towards all directions and all MSAGs are connected

				in a ring typology to make sustainable service during failure.
2	Fiber optic capacity	core	48 and 24	24 core from Mekelle to Adigrat and withi Adigrat 48 core is already installed
3	Fiber optic length	km	14.841	
4	Standard length of 10-100 pair copper wire	m	500	
5	Base stations (BTS) fiber connected to MSAGs	number	07	

Source: Ethio-telecom data record July, 2017

The network generation type in Adigrat town is 2-G and 3-G network. As it was confirmed by 74% of household and business centers and validated through observation sometimes the telecommunication services i.e. mobile services, public phone services, banking services and internet services were interrupted in Adigrat town due to telecommunication network failure. The Ethio-telecom technical staff agreed with this problem and explained that the primary reason for this service interruption was power interruption and rarely due to system failure like base station stack at faults, server faults, and fiber optic cut down.

It is more advantageous that households should have public phone because it is cheap and reliable service but in the case of Adigrat town as confirmed by all Ethio-telecom technical staff and referred in the customers list database the demand and usage of public phone is limited due the interest was shifted to mobile services.

According to Ethiopian Telecommunication Corporation and EEU installation standards the maximum operation width of infrastructure path is 3 meters but in the case of Adigrat town it is about less than 1 meter between buildings and road end as it was verified through observation and confirmed by 88.89% of Ethio-telecom technical staff all respondents from EEU and town municipality. Therefore this problem was very critical and should be given high priority.

4. Conclusion and recommendation

4.1. Conclusion

As already analyzed and interpreted in the analysis part the findings from this survey are listed below.

- ❖ In Adigrat town 2723 households were in the waiting queue taking turn to get electricity access and 21.44% of the households in the town have no sufficient electric access that can address all their needs. Generally the electric access within the town is not adequate.
- ❖ The number and level of qualification of technical staff in EEU was not to the required and the service was also very limited as determined in the survey and confirmed through observation. The level of service provided by EEU in terms of maintenance quality and access, energy consumption reading, allocating KWHMs with appropriate size to customers, inspection and installation of power distribution lines on time was not satisfactory.
- ❖ In Adigrat town infrastructure area is too small i.e. EEU's and Ethio-telecom's pole erection and device installation was not done at appropriate distance from main road and building.
- ❖ Due to narrow infrastructure area many collisions between vehicle and pole, transformer and Switch board were happened, power lines are also running over buildings.
- ❖ There was frequent power interruption in the town i.e. on average 3-5 times a day due to
  - ✓ Short circuit problem occurred due to wind, trees, rain and vehicle collision with electric pole and direct contact of phase line with neutral.
  - ✓ Overloaded system i.e. the transformer erected at a particular location carries a load more than its capacity and the three phase lines also carries different load which implies one phase is overloaded and another phase is under loaded.

- ✓ No robust protection devices at appropriate distances within the town

- ❖ There was no integrated excavation work during power cable and fiber optic cable extension in underground paths in which this problem by itself was creating material destruction and service interruption.
- ❖ There was inadequate street lighting in the town and it lacks on time maintenance.
- ❖ The power distribution network in the town was very old.
- ❖ The number of technical staff and level of qualification in EEU was not to the required.
- ❖ There was no well prepared and detail neighborhood and master plans for electric power distribution networks in the town. For Ethio-telecom the telecommunication network's neighborhood and master plans include to the level of line distribution box but not to the level of households.
- ❖ The root causes for electric hazards in the town were electric power lines contact with buildings, short circuit, vehicle collision with electric pole, and power cable drop down.
- ❖ The primary cause for telecommunication service interruption was power interruption.
- ❖ The service quality of Ethio-telecom was good and the level of telecommunication network access to every house hold was adequate because the base station is available in every corner of the town for mobile users.
- ❖ The current Ethio-telecom infrastructure needs expansion from the MSAGs point on wards and erection and installation of additional base stations connected through fiber optic to cover surrounding areas sufficiently.
- ❖ Both the electric power network and telecommunication network were found with good future extension mode to satisfy future demand of the town. But both infrastructures need expansion and upgrade.

4.2.Recommendation

The list of recommendations related to Electric power and Telecommunication network infrastructure as studied during this survey are shown below.

- ❖ The electric power network within the town needs to have robust protection devices at appropriate distance to protect surge currents and power interruption at town level
- ❖ EEU should allocate the required size KWHMs to households considering future demand.
- ❖ EEU should improve its maintenance quality and upgrade the old electric power network within the town
- ❖ EEU should improve its staff in number and qualification to provide quality service to its customers
- ❖ The municipality should establish a coordination center to coordinate and put in place integrated infrastructure work
- ❖ The municipality should leave the standard size infrastructure area 3 meters width in one side and 6 meters in both sides left and right
- ❖ The street light access in the town was found inadequate and need to be improved and its maintenance should be on time.
- ❖ The EEU and Ethio-telecom must have neighborhood and master plans for their own infrastructure integrated to the town master plan

Appendix: Map of Adigrat town with a scale of 1:24,000

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