ANALYSIS AND REDUCTION OF 11KV DISTRIBUTION LINE LOSSES OF HESCO

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Abstract: This research is a study on reduction of energy loss in the distribution system. This research is done in the power distribution system using the PSS SINCAL / adept program as a modelling tool. A considered method for reducing technical losses adds new equipment (transformers) and increases the transmission capacity of the power distribution system by reconfiguring the network based on the optimal power flow. Causes of the loss reduction. The advantage is to reduce the energy cost of the distribution system. Profit is calculated at a cost that will indicate the economic basis for investing in a source of finance that will reduce losses. In model studies using Qasimabad Grid Station of HESCO a method of reducing energy loss based on optimal power flow, combined with cost-benefit analysis and increasing the power of the power distribution system by adding new equipment, which will explain. This method was implemented on the example of a real distribution system of one of the regions Qasimabad Grid Station HESCO. Studies have shown that a transformer can help reduce energy losses in a network. Transformer costs can be offset by reduced losses. Therefore, an additional transformer can significantly improve the performance of the distribution system and reduce energy loss. Network reconfiguration should be applied correctly, but if used improperly, there is a large loss of energy. Finally, when developing an appropriate plan, the installation of the transformer will be executed correctly and operated.

Keywords: *Hyderabad Electric Supply Company; Energy Loss Reduction; High Tension; Kilo Volt; Low Tension; Pole Mounted Transformer; Geographic information system; Siemens Network Calculation*

1. Introduction

Electricity demand has increased drastically due to growing population and industrialization in developing countries and therefore it has become important to operate power plant that deliver energy to transmission and distribution lines at maximum efficiency. The existing condition of losses in the electrical power sectors are worrisome and that on the average, figures for declaration range between 25% and 40%, in some developed and developing countries, these are indeed high. For instance, the Pakistan. The network has a large proportion of transmission and distribution losses, and these amount to a whopping 40%. In Pakistan, electricity losses during transmission and distribution are extremely high and vary by 30% to 45% (Pakistan Power Economy, 2018) in 2018. In 2017-2018, electricity demand in Pakistan outstripped supply by 15-22% due to high energy losses during transmission and distribution (Electricity Sector in Pakistan, 2018) [1]. The HESCO power distribution system consists of an 11kV transmission line passing through the load zone. The distribution transformer is installed in a place suitable for reducing the voltage to the level of use (230/415 V). The secondary side of the distribution transformer (LT circuit) passes through the service area, connecting the consumer and the public network through the service cable [2]. technical losses consist of natural losses associated with heat dissipation in components of the power supply system, such as transmission and distribution lines, transformers and measuring systems, while non-technical losses, on the other hand, are usually associated with theft arising from commercial, administrative, and non-payment losses. All these losses translate to high operating costs as well as huge revenue losses to utilities and consequently they result in high cost of electricity. Since system loss represents a considerable cost for utilities, customers and host country, its evaluation and reduction have been recognized as a unique area of interest [3]. The voltage below the minimum or voltage above the maximum acceptable level are encountered. Hence, people will be exposed to the danger, poor quality and high cost of electricity which is not acceptable by industry. It is therefore necessary to evaluate and mitigate (minimize) technical losses to enhance transmission network efficiency and high-quality supply of electricity to end-users with reliability and economy [4].

Table.1. PPI Losses Evolution Final Report 2018

Transmission Line Losses (%)	HT Losses (Line + T/F) (%)	LT Line Losses (%)	PVC Losses (%)	Total Technical Losses of HESCO
3.0	11.28	3.65	1.2	18.93%

2. Related Work

The technical loss of the energy system happens naturally as a result of it consists within the loss of energy from the parts of the electrical system, like lines, transformers, connections, activity systems and different instrumentality that exchange energy with customers [5]. Technical losses also are stated as "physical losses" as a result of they visit energy that is physically lost once heat or noise becomes

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distributed throughout energy distribution. This energy consumption offers customers cash and contributes to carbon emissions [6]. Technical losses occur as an on the spot results of the physical characteristics of the electrical instrumentation employed in the distribution network. They conjointly vary looking on the electrical network style, voltage level and conversion, and even cable's length [7]. Technical losses related to instrumentation lines, transformers, and investments in long-run signals represent a compromise between investment and operational prices. They are conjointly associated with effective designing and style of electrical networks [8]. All the conductors, whether transformer coils, aluminum or copper wires in overhead lines or cables and even in switching equipment, fuses or meters, have an internal electrical resistance that heats them when the electric current passes. Since energy losses stemming from the dissipation of heat to the environment vary with the current flowing through conductors in electrical networks, these losses are called 'variable losses. These losses are also usually referred as 'ohmic losses', 'copper losses', 'Joule losses' or 'resistive losses' [9]. As a result of variable losses changing as power flows increase and decrease (proportionally to the square of the current), the network specializes in minor losses as a result of less current than is required to transmit the same amount of energy at a higher voltage. In contrast, distribution networks (at lower voltages) are subject to higher levels of loss [10]. Additional factors such as the effect of network imbalance, power factor and power quality can also have an impact on variable losses, as they influence the value of the currents flowing through conductors [11]. Additionally, variable losses are also dependent on the length and the cross section of the conductor as they vary in proportion to the resistance. As the cross section of the conductor increases, the resistance of the conductor decreases. Therefore, the larger the cable size, the smaller the impact of the loss. The same principle applies to the variable loss of the transformer, and the cross-sectional area of the winding and the material used for this affect the variable loss. Incorrect connections between the network equipment and the damaged conductors can also cause this type of loss, since they can cause the appearance of hot spots due to a greater equivalent resistance. In general, fluctuating losses represent about two thirds to three quarters of the total technical loss of the electrical system [12]. Loss of the electrical system [12]. The establishment of an on-line system to continuously evaluate non-technical losses in the distribution system is not only indispensable, it is also a strategic need for distribution companies. Monitoring and monitoring of income protection has not been adequately addressed. All of these factors generally justify the implementation of the Distribution Management System (DMS) including the IT-based enterprise platform for providing data from the Geographic Information System (GIS) [14]. GIS provides a computerized tool to capture, store, analyze and display spatial data. This technology can be used to efficiently map and monitor the electrical network. GIS is used not only in mapping and monitoring, but also in distribution and public services throughout the world to improve the quality of employees in decision-making. The main challenge currently facing distribution companies is to monitor the technical and non-technical losses in the network. There are many commercially available software solutions that use engineering models to analyze distribution networks. Today there are several solutions that incorporate the use of spatial data for notable analysis, such as ArcFM, Milsoft Windmil, ETAP, Synergee Electric, and Bentley Electric [15]. Geographic information systems (GIS) have all shapes and sizes. Some are project-specific, others support a single initiative over a period of time. GIS is mainly used for spatial analysis and supports visualization of data in cartographic format. The database can associate large amounts of information in the system with spatial analysis. In this white paper, we focus on geographic database solutions and stress that geographic information systems (GIS) can combine information that is originally maintained in different environments. Modeling of the energy distribution system is also within the scope of the geographic information system [16]. The use of geographic information system (GIS) technology in the electricity business has become an efficient planning and decision-making tool. Geographic information systems (GIS) for database integration operations such as inquiries and statistical analysis are advantageous over other information systems. With visualization and geographical analysis, the geographic information system (GIS) becomes a unique tool in the application of electrical engineering. Benefits are demonstrated because it is possible to operate and execute essential tasks for energy management to obtain sufficient and efficient results [17]. Recent trends on how public utilities have incorporated geographic information systems (GIS) as departmental solutions for business solutions where thousands of people can access data. This survey clearly shows the capacity of the spatial correspondence information system in the management of the power grid. The spatial and attribute data of the energy distribution network of any part of the selected region of interest of this research that is currently collected, processed, managed, preserved and presented in analog form is digitized obtain. (GI) It is very important for economic planning and national development [18].

3. Problem Statement

The basic problem is the computation of the actual power loss in transferring power across a line in a transmission network. In order to evaluate the peak technical losses, the 11kV transmission network will be simulated under various aspect of unbalanced faults to examine the resulting bus voltages and line currents that can further be used to evaluate actual power losses, predict the electrical behavior of the system and proffer solutions for reducing the losses in order to enhance the transmission line efficiency. Distribution system of HESCO is having high level of technical losses.

Voltage drops have resulted in low voltages at consumer terminals. Consumers are being supplied with voltage of 200 or less. Now for public services, it will be a big problem to change the load of an overloaded network / power plant in a network / power plant with little load. It is important to analyze voltage drops and power losses of 11KV feeders to improve voltage profile and reduce technical losses in HESCO. This is a connection between the plant and the substation, which is located a few kilometers away. Most energy systems are designed to transmit energy. Moreover, the primary aim of all power systems is to maintain the continuous power balance between production and consumption at the same time all bus voltages, both in magnitude and angle, are kept within specified limits. Unfortunately, no matter how carefully designed the system, technical loss. (Grid inefficiencies or load losses) would happen as a result of heat dissipation, resulting from current utilization in the power lines which could cause power unbalance between generation and major load centres. The more the power that flows through the power lines, the more will be the current that flows and consequently the power quality will decline.

4. Research Objectives

The purpose of this research is to develop a new method to estimate and reduce technical losses in HESCO transmission lines using an 11 kV.

(i) Reduction of power losses by improving voltage conditions.
(ii) Reduction of power losses through supply side load management proposals on analysis bases.
(iii) Analysis of results and recommendations.

5. Methodology

In this method, the candidate position of the loss reduction source is first identified using the objective function that has the lowest total cost object, including the cost of the loss reduction source (substation). After resetting the state of the switch on a specific network and changing the topology, insert those devices and reconfigure the network. The candidate site was selected for the optimal allocation that causes the loss or loss of the system. And the sources of information for the reduction of losses are installed in different candidate sites and multiple candidate sites. Next, perform a cost-benefit analysis on the original candidate site that reduces the loss and achieves the optimal plan to reduce the loss repeatedly. The location and size of the selected substation creates a system benefit that is greater than the cost that would economically justify the investment. This method is presented in detail in this document and is applied to the actual energy distribution system of the power distribution system (HESCO) to find the optimal location of the cause of the loss reduction. The first and most important step in this survey is the data collection phase completed by the local GPS survey. The main objectives of the GPS survey are the following.

i. Line segment identification.
ii. Geographical reference equipment such as transformers, capacitors etc.
iii. Read the angle of each GPS pole and the poles of the intersection.
iv. Material attributes and diagram information are processed as images.

5.1 Field survey tools

Garmin GPS 78s device is used to perform survey. The projection system used for the survey is Universal Transverse Mercator (UTM), this is not a projection of a single map.

5.2 Data entry

The data collected from the field is then fed in the GIS application. Step by step data is entered regarding the poles, conductor, transformer type etc.

5.3 Data processing

After the data entry, the GPS waypoints and feeder data is then merged and validated in the GIS application for further processing.

5.4 Data conversion

The merged and validated data is then converted into the format which is compatible with the ArcGIS Software and SynerGEE electric software.

5.5. ArcGIS software

A final map of the feeder is created in the ArcGIS software with the feeder details which can be further opened in google earth for a better geographical view. In google earth a clear view of the feeder and the exact location of the poles and other equipment can be seen for the purpose of optimization.

5.6 PSS-SINCAL

Software provides very simple interface for users to formulate and analyze reliability of system. Although calculated results are complex but it shows in such a way that is easily manipulated and understandable by users. It is a software used for the modeling, simulating, and analyzing the power distribution systems.

6. Scope and Limitation

This research work fundamentally evaluates the amount of technical losses prevailing on power line and proffers loss reduction measure based on modelling technical losses and computer simulation using HESCO 11kV transmission network as a case study. Firstly, a critique of load flow and loss calculation is carried out on the existing HESCO 11kV transmission grid system to investigate the current operation of the system and also to determine if bus voltages, frequency (phase angle) and power factor are within the specified limits. To better the accuracy of technical loss evaluation, this research work applies another approach for the first time ever, to estimate the power losses at both steady-state and transient phenomena associated with HESCO 11kV transmission network using symmetrical component theory of unbalanced short-circuit faults. Here, a set of unbalanced short-circuit calculations algorithm is developed and the unbalanced faults are simulated at every node for all buses of the network using PSS SINCAL and Google map software.

7. Significance of the study

The importance of this study is to rigorously establish a dependable data on technical losses in HESCO 11kV grid system for reduction. Achieving a high accuracy and correct assessment of technical losses are pathway to analyze network losses‟ reduction and also operate energy delivery to power lines at its maximum efficiency. Technical loss estimation is important information when calculating energy losses and network planning. The ultimate achievements are to.

i. Determine technical losses as the cost of producing energy and as the price of installing new generating plants are increasing.
ii. Transfer energy over power lines with maximum efficiency and reliability, to deliver to consumers at nearly fixed voltage and frequency.
iii. Establish a rigorous and dependable data of technical losses in the HESCO transmission network available for system expansion planning, utilities desirous of minimizing the network losses, for policy makers and for researcher pursuing relevant studies.

8. Reduction in technical losses

Reduction of line losses, reduction of voltage drops, improvement of power quality, improvement of power factor, improvement of operation and maintenance of power distribution equipment, enhancement in equipment life, increased reliability and reduction of unbalanced loading at the secondary of the distribution transformers. Geographical mapping of network has been prepared using online Google Earth software, for which GPS location data in form of longitude and latitude of each of the locations was collected by this research. The same data was imported in online Google Earth software and geographical mapping was developed. Developed geographical map contains the information about the location shown in Figure 1.

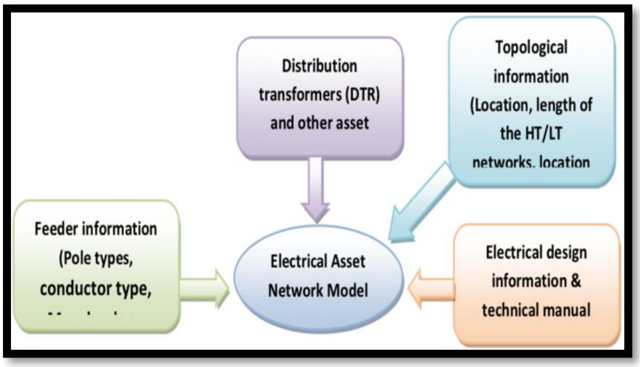

Figure.1. GIS model on electric network model of electric planning

i. HT and LT lines
ii. Power distribution transformers and their ratings
iii. Types of conductor used

9. Network Modeling

The HT side and the LT side of the 11 KV feeder are precisely modeled according to the actual data collected and the simulation is executed. The results are compared and difference in losses are presented for following 11 kV feeders. All the feeders were surveyed and simulated using PSS SINCAL software to observed technical losses. In this research to implement the energy loss reduction scheme to reduce technical losses and improve quality and reliability of services to the consumers.

9.1 Network Modeling Simulation of Electrical Network

In order to simulate the existing 11 KV network of PSS Sincal software, the following method was adopted.

i. Polar GPS position to measure the precise length between poles
ii. The type of conductor used in the network (HT / LT) and accurate use of the HESCO standard for various types of drivers is guaranteed.
iii. Distribution / capacity of transformer rated.
iv. Number of consumers supplied from each pole.
v. The feeder maximum and minimum data load (amperage) was obtained from the network it is supplied.

9.2 Purposed Area 132 KV Qasimabad Grid Station

132 KV Qasimabad Grid Station is consist on. (a) Mehran - Feeder (b) Qasimabad - Feeder (c) Duaba - Feeder (d) Sehrish Nagar - Feeder (e) G.O.R - Feeder (f) Anwar Villaz – Feeder. In this paper we were simulate three feeders

i. Mehran Feeder
ii. Qasimabad Feeder
iii. Duaba Feeder

The HT side and the LT side of the 11 KV feeder are modeled exactly like the actual data collected. 50 m service line length is considered for all consumers. Power factor is taken as 0.8 lagging. Simulation of the network is done on maximum load of the feeder.

10. Results and Discussion

High energy losses are one of the serious problems in the distribution systems in HESCO, where the distribution system is aging and the distribution lines are not always able to transmit the required active power due to the transfer capability limits. One typical example is the case of Qasimabad Grid Station Feeders of HESCO. The network of Qasimabad Grid Station Feeders was chosen as a test distribution system, the test system for the case study consisting of all radial system. The system is under in base of 11-kV distribution systems. Distribution network data technically is be converted to meet with PSS SINCAL /ADEPT parameter requirements. Then model of the present Qasimabad Grid Station network is simulated, run load flow by using the model. Hence, determine power losses in each branch of the network. Also, the candidate places for substation installation supports were defined. The identification of the candidate locations of substation installations is made according to where the highest power loss flows in the network. After each installed of substation, the costs and benefits due to loss reduction support should be estimated according to benefit cost analysis. We need to calculate benefits due to the reduced or "saved" losses from substation installations and costs of the substation installed, and then we compare benefits and costs with those substations.

10.1Simulation of 11KV Mehran Feeder

Mehran feeder originates from Qasimabad Grid station and supplies residential and commercial consumers (shops and banks) and residential consumers of the flats. L.T network is small in length of main Qasimabad from Ali Palace towards Rani Bagh in Figure 2 geographical map. There are around 46 distribution transformers installed to supply the power shown in Figure 3 and Figure 4.

Figure.2. 11KV Mehran Feeder Geographical Map

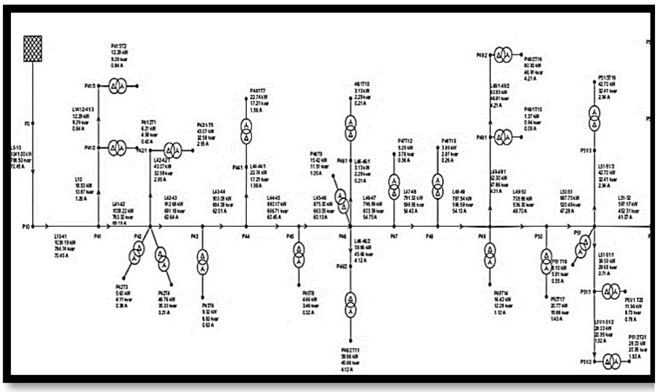

Figure.3. Simulation of 11KV Mehran Feeder (Part a)

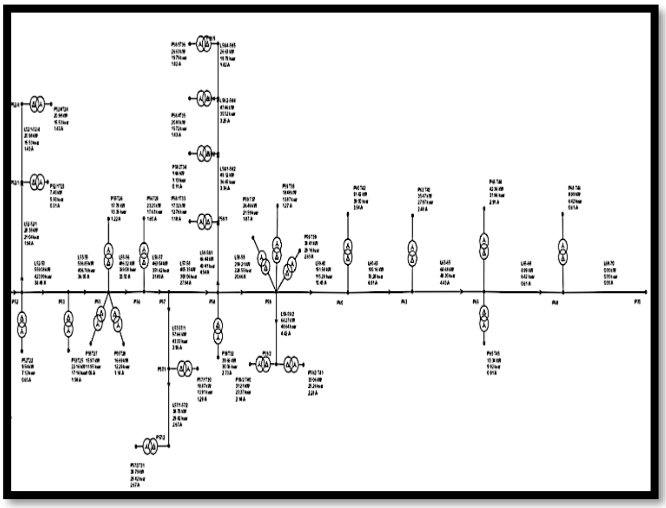

Figure.3. Simulation of 11KV Mehran Feeder (Part b)

Following Table 2 presents the simulation results of power loss i.e. HT, LT and power distribution transformers of 11KV Mehran feeder.

Table.2. Technical Losses of 11KV Mehran Feeder

Technical Losses	KW	KWH	%age
HT Line Losses	124.57	33484	3.40%
LT Line Losses	121.34	32616	3.32%
Transformer Losses	117.96	31707	3.22%
Service Losses	37.36	10044	1.02%
Total (Technical)	401.23	107851	10.96%

There are 46 PMTs which feds/distributes electricity in the area. Transformers are mostly unloaded or lightly loaded. Technical losses vary between transformers depending on line lengths and connected loads. Some of the L.T circuits are also longer in length so L.T line losses vary for different transformers in Figure 5.

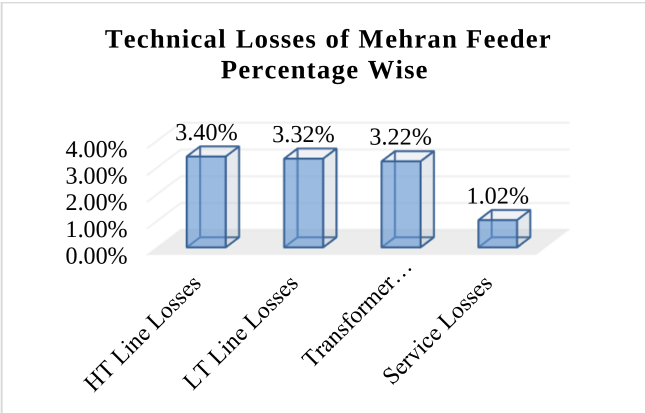

Figure.4. Technical Losses of 11KV Mehran Feeder

10.2 Simulation of 11KV Qasimabad Feeder

11 KV Qasimabad feeder originates from Qasimabad Grid station and supplies residential and commercial consumers (shops and banks) and residential consumers of the flats in Figure 6 geographical map. There are around 63 distribution

transformers installed to supply the power shown in Figure 6 and Figure 7.

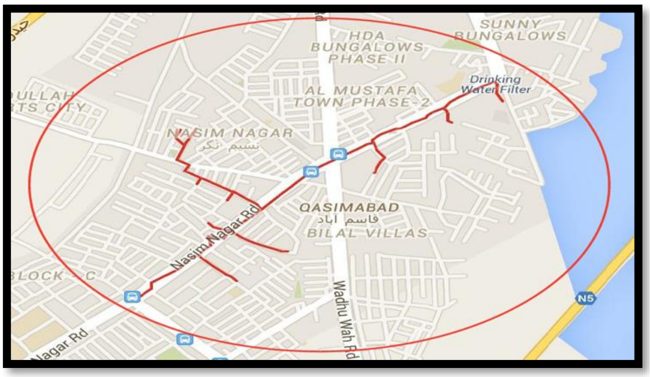

Figure.5. 11KV Qasimabad Feeder Geographical Map

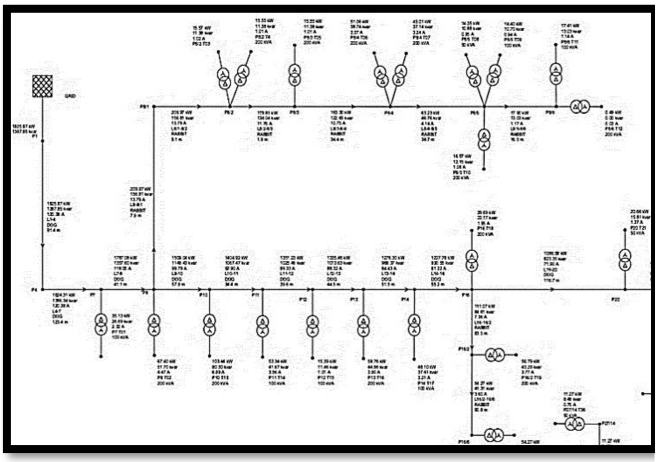

Figure.6. Simulation of 11KV Qasimabad Feeder (Part a)

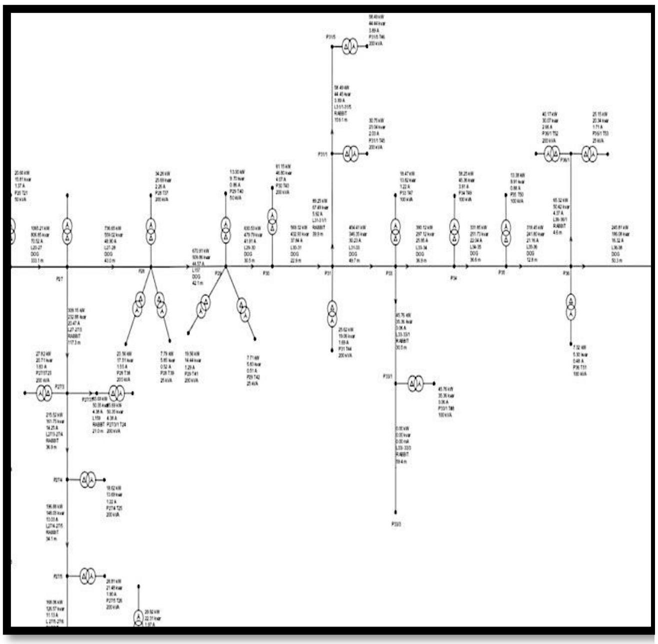

Figure.7. Simulation of 11KV Qasimabad Feeder

Following Table 3 presents the simulation results of power loss i.e. HT, LT and power distribution transformers of 11KV Qasimabad feeder.

Table.3. Technical Losses of 11KV Qasimabad Feeder

Technical Losses	KW	KWH	%age
HT Line Losses	10.31	3067.68	0.58%
LT Line Losses	15.02	4469.80	0.85%
Transformer Losses	36.36	10820.63	2.06%
Service Losses	2.74	816.20	0.16%
Total (Technical)	**64.43**	**19174.32**	**3.65%**

There are 63 PMTs which feds/distributes electricity in the area. Transformers are mostly unloaded or lightly loaded. Technical losses vary between transformers depending on line lengths and connected loads. Some of the L.T circuits are also longer in length so L.T line losses vary for different transformers in Figure 8.

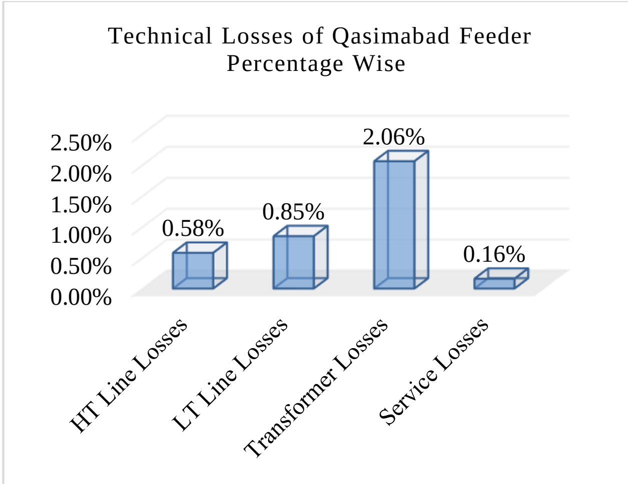

Figure.8. Technical Losses of 11KV Qaismabad Feeder

10.3 Simulation of 11KV Duaba Feeder

11 KV Duaba feeder originates from Qasimabad Grid station and supplies residential and commercial consumers (shops and banks) and residential consumers of the flats in Fig 9 geographical map. There are around 93 distribution transformers installed to supply the power shown in Figure 10 and Figure 11.

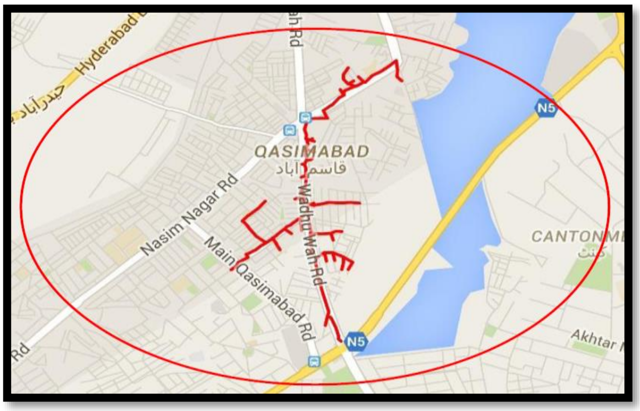

Figure.9. 11KV Duaba Feeder Geographical Map

There are 93 PMTs which feds/distributes electricity in the area. Transformers are mostly unloaded or lightly loaded. Technical losses vary between transformers depending on line lengths and connected loads. Some of the L.T circuits are also longer in length so L.T line losses vary for different transformers in Figure 12.

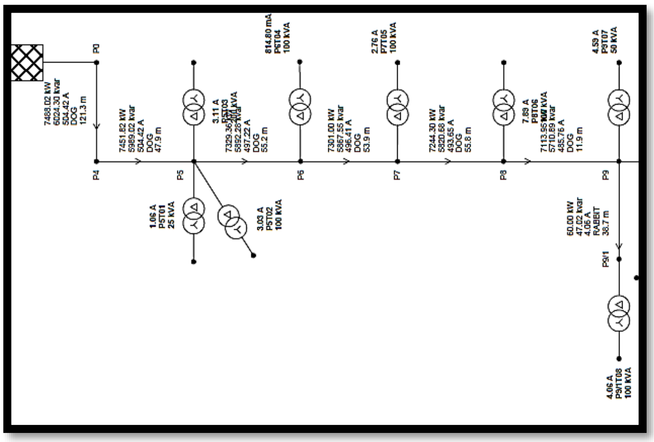

Figure.10. Simulation of 11KV Duaba Feeder (Part a)

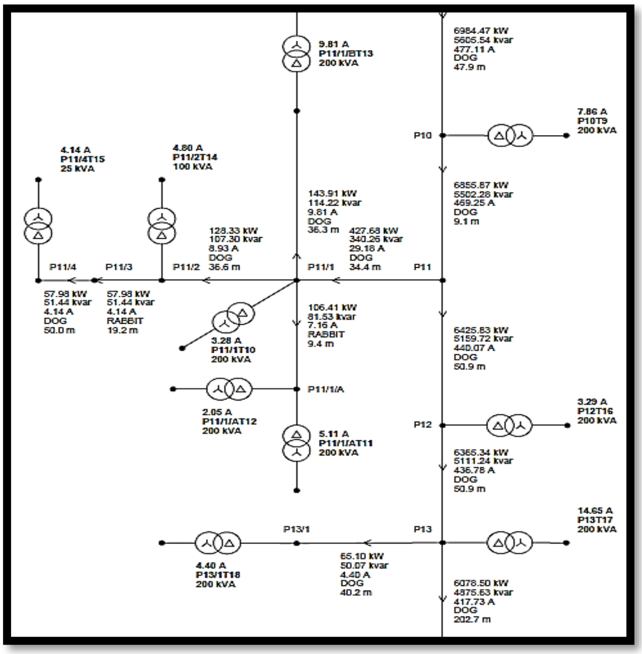

Figure. 11. Simulation of 11KV Duaba Feeder (Part b)

The following Table 4 shows simulation results of power loss, ie 11 KV HT, LT, and Duaba Distribution Transformers.

Table.4. Technical Losses of 11KV Duaba Feeder

Technical Losses	**KW**	**KWH**	**%age**
HT Line Losses	49.89	14846.73	1.54%
LT Line Losses	35.14	10457.47	1.08%
Transformer Losses	56.95	16947.73	1.76%
Service Losses	2.73	811.67	0.08%
Total (Technical) Losses	**144.70**	**43063.61**	**4.46%**

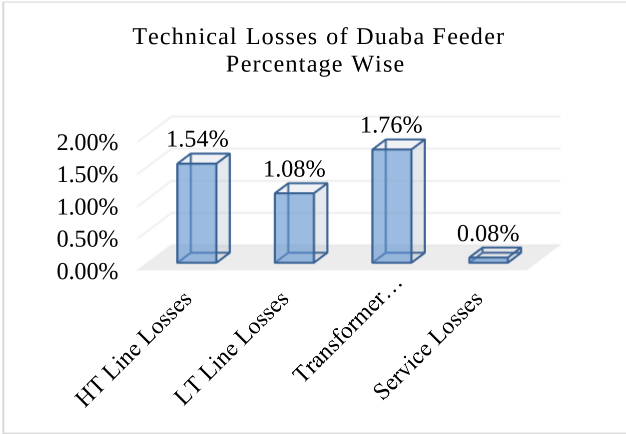

Figure.12. Technical Losses of 11KV Duaba Feeder

Simulation of feeders all transformers installed into the system show their actual peak KVA load (Peak Kw/P. F). Enter on the single line diagram the accumulated peak KVA load which it carries on each line section. At 11kv side of three phase's x-former, amps per phase is 0.05249 amperes hence this current flow in each phase conductor. Then for each line section the watt loss stands at (KVA "load" connected/diversity factor× 0.05249)² ×resistance per Km × L per Km × 3 = watts. At 6.35kv side of a single-phase x-former, amps per phase is 0.157 amperes hence this current flow in each phase conductor & return neutral. For each line section the watt loss is: (KVA "load" connected/diversity factor× 0.157) ² ×resistance per Km × L per Km × 2 = watts. Sum of the losses for all line sections, the result is the watts' demand loss for the section/feeder, naturally these watts' demand divided by 1000 is the Kw loss demand. Unequal loads unevenly disbursed require analysis by nodes and sections. But this is tedious. So, taking the peak load of the feeder and averaging it in the feeder in proper blocks; loads factors; line parameters and loss duration may be defined. The losses are due to the exciting current which energizes the cores of the transformers and is also due to the load currents flowing through the resistance of the transformer windings. The steps to be taken to determine the distribution transformer losses for each feeder are: Determine total number of single phase and total number of three phase distribution transformers. Determine total KVA of single phase and total KVA of three phase distribution transformers. Determine average capacity of single phase and average capacity of three phase distribution transformers.

11. Conclusion

The entire investigation where the problem statement and aim of the work are correlated with the obtained results. Ideas about future development, improvement and work are stated, suggestions for system performance optimization of the proposed technology are given. The research has demonstrated the effectiveness and practical reliability and its contribution in achieving optimal performance is presented with the comparisons. The cost effectiveness and suitability of the work for low voltage distribution network scenario is highlighted and possibility of energy saving in terms of few millions of rupees per month is explained. The advantage is to reduce the energy cost of the distribution system. Profit is calculated at a cost that will indicate the economic basis for investing in a source of finance that will reduce losses. In model studies using Qasimabad Grid Station of HESCO a method of reducing energy loss based on optimal power flow, combined with cost-benefit analysis and increasing the power of the power distribution system by adding new equipment, which I will explain. This method was implemented on the example of a real distribution system of one of the regions Qasimabad Grid Station HESCO. Studies have shown that a transformer can help reduce energy losses in a network. Transformer costs can be offset by reduced losses. Therefore, an additional transformer can significantly improve the performance of the distribution system and reduce energy loss. Network reconfiguration should be applied correctly, but if used improperly, there is a large loss of energy. Finally, when developing an appropriate plan, the installation of the transformer will be executed correctly and operated.

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