*Sindh Univ. Res. Jour. (Sci. Ser.) Vol. 47 (3) 469-472 (2015)*

**SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)**

# Reinforcement Proposal towards Loss Reduction in Distribution Network

A. A. SAHITO[++], M. J. JUMANI *, M. A. MAHAR**, S. A. A. SHAH**

Department of Electrical Engineering, Mehran UET, Jamshoro

Received 13th February 2015 and Revised 23rd May 2015

**Abstract:** Energy losses are degrading distribution utility performance as well as adding to already occurring energy crises. Increasing fuel prices, scarcity and competition calls for highest operational efficiency of power sector. Both technical and non-technical losses are badly affecting utilities in Pakistan and Electricity theft through direct hooking is a major contributor towards these losses. Aerial Bundled Cables (ABC) are insulated cables available with different current carrying capacities to be used as a replacement of bare overhead conductors to ensure safety of personal, reliability and ease of maintenance. Chances of direct hooking to these cables are minimum

In this paper, one of the distribution feeder in Hyderabad Electric Supply Company (HESCO) is analyzed to observe the effectiveness of ABC as energy loss reduction technique. Selected feeder is modelled and simulated for actual and modified systems and technical losses for both cases are compared. Reduction in line resistance and removal of direct connections reduce technical losses of the selected feeder from 11.23% to 9.38%. Comparison of units billed for three months of two consecutive years, shows an increase of 67% and small payback period. Simulation and economic analysis confirms that ABC is suitable reinforcement proposal for loss reduction in distribution systems of Pakistan

**Keywords:** Distribution system; Aerial bundled cables; Reinforcement of distribution system; Power loss reduction; HESCO.

## 1. INTRODUCTION

Energy crises in power sector are hampering possible growth of industry in Pakistan. Residential and commercial consumers are also feeling restless due to long duration load shedding and high electricity prices (Sahito. *et al.,* 2015). Pakistan has a mix of generation sources including hydroelectric and thermal units. Recent development and interests in renewable energies results in a very small scale wind and solar generation plants. Pakistan has huge wind corridor and sunlight for almost whole year but renewable energy generation is still not considered seriously due to initial cost (Uqaili. *et al.,* 2014). Increasing share of thermal generation initiated and ever increasing electricity tariff, which may be termed as areas on for increasing electricity theft.

Power system is combination of different sections including generation, transmission over long distances and distribution to consumer terminals for end utilization (Halepoto. *et al.,* 2015). During the process of transmitting the power from generation sources to end consumers, some portion of the power is lost in system components (Farahani, *et al.,* 2013). Additionally some of the energy is utilized by illegal means without being billed. Difference of energy generated and energy sold to various consumers is termed as energy losses. It is obvious that no system can have 100% efficiency; therefore every power system will have some energy losses.

Hyderabad Electric Supply Company (HESCO) is responsible for distribution of electricity in major portion of the Sindh province except Karachi and its surroundings. Energy losses in HESCO have remained in excess of 30% making it one of the high loss distribution companies of Pakistan (Sahito. *et al.,* 2014). Percentage losses for HESCO in year 2013-14 were 27.3%. On the other hand Islamabad Electric Supply Company (IESCO) has 9.5%, Faisalabad Electric Supply Company (FESCO) with 9.6%, Gujranwala Electric Power Company (GEPCO) with 10.5% losses are examples of DISCOs with controlled energy losses.

Overhead power lines having three phase conductors with a neutral tightly twisted together with cross linked polyethylene insulation is commonly known as Aerial Bundled Cable or Conductor (ABC). Multiple bare conductors give ugly look, require more hardware, unsafe for line maintenance staff and produce sparks during high winds or external forces, whereas ABC looks more pleasant, requires less hardware, safe to work on live line and has no chance of sparking (Morgan. 1993). It is easily installed on trees, narrow lanes and walls without any sparking and no any crossbars and insulators are needed. Replacement of bare conductors with ABC eliminate chances of direct hooking as special connection assemblies are required to tap a connection. With smaller number of wires and pleasant look, it becomes easy to monitor distribution system for any illegal connection.

[++]Corresponding Author: anwar.sahito@faculty.muet.edu.pk

*Institute of Information & Communication Technologies, Mehran UET, Jamshoro

**Department of Electrical Engineering, Mehran UET, Jamshoro`

In this paper, one of the 11 kV feeder in HESCO is selected to analyze impacts of ABC on loss reduction. Feeder is modelled as per existing data and simulated to calculate technical losses. L.T networks of transformers are modified replacing existing bare conductor with actual size of installed ABC. Direct connections observed during replacement procedure are also eliminated for simulation analysis. Economic analysis is conducted for a selected area of the feeder by comparing electricity units billed for three months of the consecutive years.

Section 2 of the paper defines energy losses and their major causes are highlighted. Section 3 contains details of the selected feeder and simulation results for technical losses. Loss reduction is analyzed through comparison of simulation results for existing and modified networks. Revenue enhancement analysis of selected portion is given in section 4 and payback period is estimated. Section 5 concludes paper and suggestions are given to replace bare conductors with ABC.

## 2. ENERGY LOSSES

Energy losses refer to the difference of electricity generated and sold in a power system. Technical losses are due to energy dissipated in system equipment e.g. conductors, cables and transformers (Ramesh. *et al.,* 2009). Technical losses depend on the network characteristics and mode of operation and are further classified in load current dependent and current independent losses. Losses independent of load current are also referred as iron losses because these are associated with transformer's iron core. Variable losses are proportional to the square of the load current and resistance of the system component. Consequently, 2% increase in current leads to 4% increase in losses. Reducing the resistance of a conductor by increasing its cross sectional area will result in reduced power losses for a given load, which leads to a trade-off between cost of losses and capital expenditure. Long length of distribution lines, small conductor/cable size, poor load power factor, improper joints caused by bad workmanship, unbalanced loading are some causes of high technical power losses. Technical losses cannot be completely eliminated but can only be minimized through system up gradation and efficient planning for its operation (Peponis. *et al.,* 1996).

Non-technical losses are caused by mismanagement in administrative procedures and electricity theft is considered as its chief cause. Bare conductors running near consumers premises are easy to hook for illegal use of electricity. **Fig.1** shows direct connections taken from bare conductors passing nearby residential building. Improperly arranged conductors and service wires make it difficult to monitor system for any illegal connection. Apart from direct connections, meter tempering is another source for electricity theft and is commonly used in urban areas (Nizar. *et al.,* 2008).



**Fig. 1: Direct Connection Taken From L.T Line**

## 3. ENERGY LOSS REDUCTION THROUGH ABC

HESCO is installing ABC on low tension (L.T) networks of 100 feeders of Hyderabad under Energy Loss Reduction (ELR) program. ABC cables used to replace bare conductors consist of three All Aluminum Conductors (AAC) for three phases and one Aluminum Alloy Conductor for neutral wire. Additionally a smaller size phase wire is also provided for street lighting connection. ABC was used in Australian power systems in 1983 partly in response to bushfires sparked by old wires touching (Williamson. *et al.,* 1988). ABC is available in different sizes and current ratings to meet with load requirements as given in **Table 1.** Replacement of bare conductors through ABC results in aesthetic beauty and ease of monitoring as shown in **Fig.2.**

**Table 1. ABC Current Carrying Capacity**

| Sr. # | Cable Size (mm2) | Current Carrying Capacity (A) | HESCO Code |
|---|---|---|---|
| 1. | 95 | 257 | A |
| 2. | 70 | 212 | B |
| 3. | 50 | 168 | C |
| 4. | 16 | 93 | D |




**Fig. 2: Aesthetic Comparison of ABC and Bare Conductor**

To understand impacts of replacing bare conductors with ABC, 11 kV GOR feeder is selected for analysis. It originates from 132kV Qasimabad substation Hyderabad and supplies areas of Memon society, Muslim society and surroundings. Most of the consumers are residential bungalows with some kachi abadis near these societies. Field surveys and meetings with HESCO officials were carried to collect technical data of the feeder. Collected data include span lengths for both H.T and L.T lines, type of the conductor used, transformer capacity and location. Standard data base for the conductors and transformers were used for their electrical parameters. Number of legal and illegal connections were carefully checked at each pole and included for analysis

Collected data revels that length for 11 kV line of this feeder is 8.07 km and it has 62 installed transformers to supply consumer loads. Total capacity of the transformers is 9525 kVA and details are given in (**Table 2).** Approximately 2600 consumers having sanctioned load of 6800 kW are supplied through the feeder. Energy losses of GOR feeder for last two years are recorded as 29.17% and 28.49%.

**Table 2. Transformer Details of 11kV GOR Feeder**

| Transformer Rating (kVA) | Quantity | Capacity (kVA) |
|---|---|---|
| 25 | 5 | 125 |
| 50 | 2 | 100 |
| 100 | 23 | 2300 |
| 200 | 29 | 5800 |
| 400 | 3 | 1200 |
| Total | | 9525 |

. Power System Simulator Siemens Network Calculator (PSS SINCAL) software is used to model existing network of selected feeder using collected data. L.T network of each transformer is modelled separately and linked with H.T network. 11 kV network consists of 11 kV lines and transformers and its small portion for power flow analysis**.** L.T circuits starts with secondary terminals of transformers and consist of L.T and service lines. Simulation analysis is performed to observe technical losses in different line sections and transformers for existing system. Conductors in L.T network of 40 transformers are replaced by ABC and these circuits are modified according to the parameters of installed ABC. Direct connections taken from bare conductors have been removed in modified circuits of L.T networks. Modified networks are simulated again to observe changes in technical losses on feeder.

Results of simulation analysis for selected feeder given in (**Table 3)** show considerable loss reduction through replacement of bare conductors with ABC. Losses are divided into conductor and transformer losses whereas conductor losses are further divided into H.T, L.T and service lines. Losses in L.T lines show most significant reduction of 80.16 kW (1.67%) because bare conductors in these lines have been replaced with ABC having less resistance. Additionally direct connections are eliminated for simulation analysis, resulting in reduction in currents flowing through different branches.

**Table 3: Technical Losses of GOR Feeder**

| Lines / T/Fs | Power Losses (KW) | | | %age Loss | | |
|---|---|---|---|---|---|---|
| | Existing | Modified | Diff: | Existing | Modified | Dif |
| H.T | 99.09 | 93.50 | 5.64 | 2.09 | 1.99 | 0.10 |
| L.T | 275.10 | 194.94 | 80.2 | 5.81 | 4.15 | 1.67 |
| Service | 62.53 | 61.40 | 1.13 | 1.32 | 1.31 | 0.02 |
| T/Fs | 94.41 | 91.00 | 3.42 | 2.00 | 1.94 | 0.06 |
| Total | 531.13 | 440.78 | 90.4 | 11.23 | 9.38 | 1.85 |

These reduced currents result in reduced energy losses. Reduction in transformer losses is contributed by reduction in currents caused by disconnected direct connections and reduced losses for L.T and service lines. Although there has been no reinforcement of H.T lines, still energy losses have reduced because of reduced current flows caused by disconnected illegal loads and reduced power losses transformers, L.T and service lines.

## 4. ECONOMIC ANALYSIS

Power loss reduction through network simulation explained in section 3 represents technical losses of the feeder. It is observed that technical losses on the selected feeder network were 11.23% whereas power losses recorded for last year is 28.49% indicating approximately more than 17% portion for non-technical losses corresponding to electricity theft. 13 transformers of residential area energized by 11 kV GOR feeder are selected for economic analysis as case study. Meter reading data is collected for three months of June to August 2014 for these transformers and compared with the consumption data for three months from June to August 2013 and is summarized in **Table 4**. Significant increase in units recorded is observed for all the considered transformers. Some of the transformers show more than 100% increase in billed units. Significant increase in billed units for the selected transformers indicates reduction of electricity theft as a result of ABC replacing bare conductors and monitoring.

As seen in the **Table 4**, there is increase of 251864 in billed units for 13 transformers considered for analysis. In addition to this 67% increase, 313 direct connections were removed during replacement work. Considering an average sell price of Rs. 15 per kWh, amount saved for three months is Rs. 3777960. Estimated cost for replacement of bare conductors with ABC for these 13 transformers is approximately Rs. 69,55,000. Therefore 54.3% of the investment cost is recovered from increase in billed units for three months and expected payback period is nearly half a year.

**Table 4: Comparison of Recorded Energy Consumption for 13 Selected Transformers of GOR Feeder**

| Sr. # | Number of Connections | Energy Consumption Recorded for June to Aug (kWh) | | Increase in Recorded Energy Consumption | |
|---|---|---|---|---|---|
| | | 2013 | 2014 | kWh | % |
| 1 | 138 | 43642 | 61550 | 17908 | 41% |
| 2 | 22 | 13353 | 22957 | 9604 | 72% |
| 3 | 31 | 26806 | 49173 | 22367 | 83% |
| 4 | 27 | 20114 | 29880 | 9766 | 49% |
| 5 | 46 | 28381 | 50945 | 22564 | 80% |
| 6 | 85 | 48184 | 76535 | 28351 | 59% |
| 7 | 83 | 34802 | 52655 | 17853 | 51% |
| 8 | 60 | 14952 | 25255 | 10303 | 69% |
| 9 | 60 | 18202 | 31065 | 12863 | 71% |
| 10 | 18 | 18613 | 42580 | 23967 | 129% |
| 11 | 144 | 55175 | 74437 | 19262 | 35% |
| 12 | 23 | 8554 | 17694 | 9140 | 107% |
| 13 | 62 | 46502 | 94418 | 47916 | 103% |
| **Total** | **799** | **377280** | **629144** | **251864** | **67%** |

## 5. CONCLUSION

Impacts of ABC for loss reduction are analyzed by selecting one of the 11kV feeder in HESCO for simulation and financial data. Selected feeder was modelled and simulated with existing and modified networks for comparison of technical losses. Removal of direct connections and reduction in line resistance through replacement of bare conductors on L.T networks with ABC resulted reduced technical losses from 531.13 kW (11.23%) to 440.78 kW (9.38%). ABC results in better system monitoring making it easier to detect an illegal connection, resulting in reduction of electricity theft. Economic analysis of thirteen selected transformers reveled an increase of 251864 (67%) in billed units for three months. Payback period for replacing bare L.T conductors with ABC is estimated to be less than one year. ABC also improves system reliability as number of faults for loose jumpers, broken conductors and short circuit under heavy winds are minimized. Insulated conductors increase safety of line maintenance staff and common man. Additionally replacing existing energy meters with smart meters will further help to reduce energy losses and it is proposed for future work.

## 6. ACKNOWLEDGEMENTS

Authors are thankful to Mehran University of Engineering and Technology Jamshoro for providing guidance and necessary resources. We are also thankful to Project Management Unit (PMU) of HESCO for providing necessary data.

## REFERENCES:

Farahani, V., S. H. H. Sadeghi, H. A. Abyaneh, S. M. Agah, (2013). “Energy Loss Reduction by Conductor Replacement and Capacitor Placement in Distribution Systems”, IEEE Transactions on Power Systems, 28(3), 2077-2085.

Halepoto, I. A., A. A. Sahito, G. M. Shoro, (2015). “Design of Integrated Analytical Process Framework for Smart City Transformation based on Strengths-Weaknesses-Opportunities-Threats Analysis.", Sindh University Research Journal- SURJ (Science Series), 47(2). 221-230.

Morgan, V. T. (1993). "External thermal resistance of aerial bundled cables" In IEE Proceedings (Generation, Transmission and Distribution), 140(2), 65-72.

Nizar, A. H., Z. Y. Dong, Y. Wang (2008). "Power utility nontechnical loss analysis with extreme learning machine method", IEEE Transactions on Power Systems, 23(3), 946-955.

Peponis, G. J., M. P. Papadopoulos, N. D. Hatziargyriou, (1996). “Optimal operation of distribution networks,” IEEE Transactions on Power System, 11(1), 59–67.

Ramesh, L., S. P. Chowdhury, S. Chowdhury, A. A. Natarajan, C. T. Gaunt, (2009). “Minimization of Power Loss in Distribution Networks by Different Techniques”, International Journal of Electrical Power and Energy Systems Engineering, 2(1).1-6.

Sahito, A. A., I. A. Halepoto, S. M Tunio, (2014). “Application of Infrared Thermography in Power Distribution System”, Mehran University Research Journal of Engineering & Technology, 33(3), 352-358.

Sahito, A. A., I. A. Halepoto, M. A. Uqaili, Z. A. Memon, A. S. Larik, M. A. Mahar, (2015). “Analyzing the Impacts of Distributed Generation Integration on Distribution Network: A Corridor Towards Smart Grid Implementation in Pakistan”. Wireless Personal Communications, vol. 64 (3): 1-19.
(DOI) 10.1007/s11277-015-2754-y

Uqaili, M. A., A. A. Sahito, I. A. Halepoto, Z. A. Memon, S. B Dars, (2014). "Impact of distributed generation on network short circuit level" In IEEE 4th International Conference on Wireless Communications, Vehicular Technology, Information Theory and Aerospace & Electronic Systems (VITAE), 1-5. Denmark.

Williamson, C. E., M. P. Garner, K. W. Barber, and R. F. Elford, (1988) "Development and introduction of aerial bundled cables in Australia." In IET International Conference on Overhead Line Design and Construction: Theory and Practice, 113-117. London, UK.