Sindh Univ. Res. Jour. (Sci. Ser.) Vol.48 (1) 53-56 (2016)

SINDH UNIVERSITY RESEARCH JOURNAL (SCIENCE SERIES)

Network Reconfiguration for Power Loss Reduction in Distribution System

S. P. GHANGHRO*, A. A. SAHITO++, S. A. MEMON, M. J. JUMANI**, S. M. TUNIO

Department of Electrical Engineering, Mehran UET, Jamshoro

Received 27th June 2015 and Revised 21st November 2015

Abstract: Distribution utilities in Pakistan are suffering from high power losses. High technical losses and electricity theft not only affect performance of a distribution losses but add to already existing demand supply gap. Electricity consumers are affected from these scenarios. High electricity tariff, long duration load shedding and unplanned frequent supply trappings are being faced by electricity consumers. Network reconfiguration refers to change in existing system structure to enhance its performance by changing circuit parameters.

In this paper, one of the distribution feeder in Hyderabad is selected for analysis of power loss reduction using network reconfiguration. An efficient network reconfiguration technique is proposed based on conversion of low voltage lines to high voltage lines. Existing transformers are replaced with two or more transformers with smaller capacities. Proposed reconfiguration technique reduce current flows and eliminates chances of direct connections from low voltage lines. Simulation of existing and proposed systems is performed using Power System Simulator, Siemens Network Calculator (PSS SINCAL) software. Results are analyzed for bus voltages and power loss reduction. Effectiveness of the proposed reconfiguration technique is confirmed through simulation results.

Keywords: Distribution system; Power losses; Network reconfiguration; HESCO.

1. INTRODUCTION

Electricity sector of Pakistan is facing worst energy crises of its history. Generation is unable to match with rapidly increasing energy demands resulting in long duration load shedding (Sahito, *et al.* 2014). Despite of energy conservation policies and drives of reducing loads by replacing conventional illuminations sources with energy saving compact fluorescent lamps and using high efficiency motors in industries, power demand is growing regularly (Uqaili, *et al.* 2014). On the other hand no prompt action is taken for increasing power generation. Some of the projects are under construction but it is expected that when these plants will be added to system, demand would have been increased even beyond their capacities.

Old aged distribution and transmission network and improper operation results in high technical losses. Direct connection to low tension (L.T) lines and tempering with energy meters results in high amount of electricity theft mainly referred as non-technical losses (Aguero, 2012). Total losses of the distribution system increase to unacceptable level. Decreasing power losses is a quick method to reduce demand on generation. It improves efficiency of the system and thus will reduce overall cost of operation, which may result in reduced energy prices for consumers. Hyderabad Electric Supply Company (HESCO) is responsible for power distribution in lower part of the province of Sindh. The problem of energy losses is badly affecting performance of Pakistan's power sector in general and HESCO in particular (Farhana, *et al.* 2013).

Network reconfiguration refers to alteration of existing network physically or electrically. Changing route of transmission and distribution lines, bifurcation of distribution feeders, shifting of load to other less loaded feeder and changing system operating voltages are some of the examples for network reconfiguration (Rao, *et. al.* 2013). Network is reconfigured to minimize power losses under normal operating conditions. In case of any fault, network may be reconfigured for supply restoration to affected areas (Dai. *et al.* 2015).

(Amanulla, *et al.* 2012) analyzed power loss reduction considering reliability aspects. Using binary particle swarm optimization algorithm they showed power loss reduction through network reconfiguration. (Farhani, *et al.* 2011) used single branch modification method for loop type system to show power loss reduction and voltage improvement. (Nguyen and Truong, 2015) used cuckoo search algorithm for optimal reconfiguration of distribution system. They concluded that power losses are reduced and bus voltages are improved.

In this paper, new reconfiguration technique is proposed for loss reduction especially useful for Pakistan scenario. Lines are converted to high tension (H.T) lines and transformers are replaced with smaller capacity transformers. Reduction in current reduce power losses and voltage drops in the system. Absence of L.T conductors and installation of energy meters at pole mounted transformers (PMTs) makes electricity

++Corresponding Author: anwar.sahito@faculty.muet.edu.pk
*Institute of Information and Communication Technologies, Mehran UET, Jamshoro`
** Project Management Unit (PMU), HESCO Hyderabad

theft almost impossible. Thus proposed reconfiguration is suitable for both technical and non-technical losses.

Rest of the paper follows as given here. Section 2 describes energy losses in distribution system. Technical and non-technical losses are discussed with causes commonly seen in Pakistan. Section 3 illustrates different reconfiguration techniques and proposed reconfiguration method is explained. Section 4 contains simulation results and discussions for selected feeder of HESCO to observe effectiveness of the proposed technique. Paper is concluded in section 5 and recommendations are given based on the results of the research work.

2. ENERGY LOSSES

Energy losses may be defined as the difference of energy supplied and energy billed. That can be classified into two categories

1. Technical losses
2. Non-technical losses

Technical losses are due to inherent electrical properties of system components. Fixed or iron losses occur in transformer core and are independent of load current. Copper or variable losses are dependent on load current and occur in conductors, cables and transformers and are given as (Sahito, *et al.* 2015)

$$P_L = I^2R \qquad (1)$$

Where I = current flowing through equipment
and R = resistance of the equipment
From Eq. 1 it is clear that technical power losses depend upon resistance and current flowing through a circuit. Aged distribution system, under size conductors, improper maintenance, loose connections, improper joints and jumpers are some of the causes for high resistance of lines and transformers and thus contribute to technical power losses. Over loading, unbalanced loading, poor load power factor and improper reactive power compensation cause increase in current and thus contribute to power losses.

If current (I) is reduced, power losses will be reduced proportional to its square. For constant power loads, if voltage is increased then current will decrease in the same proportion. This fact is the basis for extra high voltage (EHV) transmission system. Therefore power losses of the system will reduce if voltage is increased for distribution lines. Similarly shunt capacitors near the load will compensate for the reactive power requirements of the load and thus currents flowing through conductors and transformers are reducing resulting in reduction of power losses.

Non-technical losses are caused by mismanagement in billing procedures and electricity theft. Direct hooking from L.T lines is commonly employed technique for electricity theft especially in rural areas. Replacement of bare L.T conductors with insulated Aerial Bundled Cables (ABC) is employed in different areas of HESCO to control electricity theft through direct hooking. ABC have reduced power losses but now consumers are taking direct connections by removing insulation from service lines. Energy meter tempering is also employed for electricity theft. Meters installed on the walls of the consumers make it easy to temper and alter flow of current and use electricity without being billed.

3. NETWORK RECONFIGURATION

Network reconfiguration refers to alteration of existing network physically or electrically. Changing route of transmission and distribution lines, bifurcation of distribution feeders, shifting of load to other less loaded feeder and changing system operating voltages are some of the examples for network reconfiguration. Network is reconfigured to minimize power losses under normal operating conditions. In case of any fault, network may be reconfigured for supply restoration to affected areas. In addition to network reconfiguration, reinforcement of network components by increasing capacity is also considered as part of the reconfiguration. For example increasing current carrying capacity of an overhead line conductor or using a transformer with a different kVA rating (Capitanescu, *et al.* 2015).

Distribution system reconfiguration has assumed significant importance. The present trend towards competitive business environment has forced modern electric utilities to operate their distribution systems as efficiently as possible by minimizing the distribution loss. The distribution loss for a given load depends on distribution network configuration. The network reconfiguration is done by changing the ON/OFF status of sectionalizing/tie switches. The aim of distribution system operator is to reconfigure the distribution network in response to changing load demand or other conditions in such a fashion that distribution loss is minimum, network remains radial with all operating constraints satisfied. Since, there may be large possible switching combinations, finding an optimal switching combination is a difficult optimization problem. Reconfiguration of feeder is most important function of automated distribution system used to reduce feeder losses in distribution and load balancing to improve system security (Imran, *et al.* 2014). The optimal reconfiguration model responds to changes in the network topology by switching the automatic breakers installed in the network.

Distribution system in Pakistan starts from distribution substation where 132kV is stepped down to 11kV. In some areas 33kV voltage level is used in place of 11kV. 11kV feeders emit from distribution substation and run through service area. PMTs are installed in service areas to step down 11kV to utilization voltage of 400/230V. There after secondary system of L.T lines run in service area. Service mains are connected to these L.T lines. Long length of L.T lines produce high technical losses and are easy to hook for electrical theft. Many distribution system of low voltage (400V) in towns are covered by high voltage feeders. More conductor current flow when voltage is low resulting high power losses.

Replacing low voltage network to high voltage network will result in reduction in technical losses and electricity theft. **(Fig. 1)** shows concept of proposed network reconfiguration. **(Fig. 1(a)** shows existing system where L.T lines are shown connected to secondary of the PMT. Loads are taken from secondary L.T circuits. **(Fig. 1(b)** shows proposed system where one transformer is replaced by two transformers. Loads are directly supplied from transformer structure and meters are installed at PMT pole. Removal of L.T line reduces current flows resulting in less technical power losses. On the other hand absence of L.T lines makes it impossible to directly hook for illegal use of electricity.

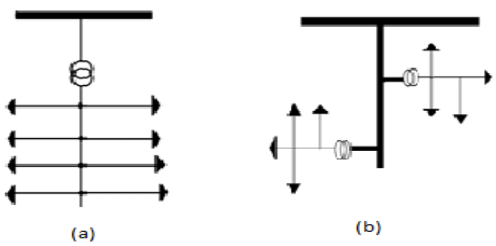

Fig. 1: L.T circuit model (a) Existing (b) Proposed reconfiguration

4. RESULTS AND DISCUSSION

Most of the 11 kV feeders in Hyderabad city supply residential and commercial consumers. 11 kV Hayat is one of such feeder supplying electricity to portion of Sarfaraz colony, Al Rahim shopping center and surroundings (Sahito, *et al.* 2015). It has 4.85 MVA of connected load through 31 PMTs of different kVA ratings to supply consumers. **(Fig. 2)** shows one line node diagram for H.T network. Existing network is modelled and simulated using PSS SINCAL software to observe power losses.

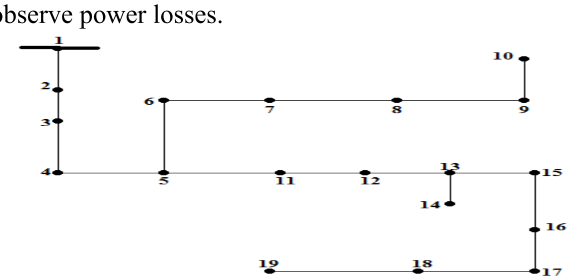

Fig. 2: Node diagram of 11kV Hayat feeder

(Table 1) shows comparison of transformer wise power losses for 31 PMTs of the selected Hayat feeder. For each existing transformer, number and capacities of the transformers proposed for reconfiguration are also given in **(Table 1).** Transformer 1 shows same capacity in existing and proposed systems. In this case only energy meters are shifted and secured at PMT pole. Transformer 2 shows that existing 200kVA transformer is replaced by two 100kVA transformers. Similarly 200kVA transformer 11 is replaced by 4 transformers, each rated 50kVA.

Loads for simulation of existing systems are considered balanced. It is observed from table 1 that power losses in existing system are 230.68 kW. Losses after proposed reconfiguration system are reduced to 61.29 kW indicating a reduction of 169.39 kW. On the other hand H.T network shows a loss reduction of 26.14 kW from 91.2 kW of existing system to 65.06 kW of proposed system. Hence it can be seen from simulation results that proposed reconfiguration scheme reduces power losses of 195.53 kW for selected Hayat feeder. This reduction in losses is mainly caused by removal of L.T lines. Some of the L.T lines are converted in H.T where current is reduced and thus considerable power loss reduction is observed. Losses in H.T network are reduced due to reduced losses in L.T networks.

Table 1: Comparison of power losses for balanced and unbalanced loading on 11kV Hayat feeder

	Transformer (kVA)		Power Losses (kW)		
Sr.	**Exist.**	**Prop.**	**Exist**	**Prop.**	**Diff**
1	50	1*50	1.6	0.883	0.72
2	200	1*100 + 2*50	8.27	2.058	6.21
3	200	1*100 + 2*50	3.64	1.706	1.93
4	200	1*100 + 2*50	15.29	2.729	12.56
5	200	1*100 + 2*50	13.21	2.356	10.85
6	200	2*100	13.70	2.516	11.18
7	200	2*100	5.57	3.278	2.29
8	200	1*100 + 2*50	1.56	0.639	0.92
9	100	1*100 + 2*50	3.67	2.85	0.82
10	100	2*50	3.67	3.131	0.54
11	200	4*50	5.01	2.483	2.53
12	100	2*50	1.03	0.031	1.00
13	200	2*100	10.99	1.608	9.38
14	200	2*100	5.52	1.072	4.45
15	50	1*25	0.77	0.488	0.28
16	200	2*100	14.47	3.653	10.82
17	200	1*100	10.98	1.804	9.18
18	200	2*100	5.24	1.667	3.57
19	25	1*25	0.61	0.436	0.17
20	25	1*25	0.76	0.511	0.25
21	200	2*100	13.78	3.817	9.96
22	200	4*50	4.79	2.353	2.44
23	200	2*100	5.13	2.008	3.12
24	200	2*100	9.71	1.133	8.58
25	100	1*100	4.42	1.508	2.91
26	200	2*100	17.59	3.837	13.75
27	100	1*100	7.53	1.503	6.03
28	100	1*100	4.43	2.663	1.77
29	200	2*100	2.39	1.955	0.44
30	200	2*100	19.89	2.663	17.23
31	100	1*100	15.95	1.955	14.00
	Total		230.68	61.29	169.37

On the other hand chances for electricity theft through direct connections are almost eliminated as L.T conductors are completely replaced by H.T lines. Meters are proposed to be installed at poles of PMTs. For direct hooking, one has to connect direct from transformer bushings and bring to utilization premises. Hence it becomes easy to monitor. Meter readings will also be easier **(Fig. 3).**

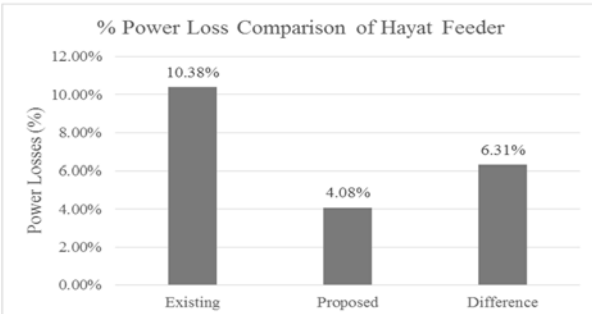

Fig. 3: Percentage Power loss comparison of 11kV Hayat feeder

5. CONCLUSION

This paper focuses on distribution feeder power losses reduction through network reconfiguration. 11kV Hayat feeder supplying residential and commercial consumers in Hyderabad is modelled and simulated using PSS SINCAL software to observe effectiveness of the proposed network reconfiguration scheme. Conversion of L.T overhead conductors to H.T and installing energy meters at PMTs eliminate chances of direct connection for electricity theft. Increased voltage of the H.T lines results in less current flowing through proposed system resulting in reduced power losses. Proposed system is easy to implement in rural areas and most of the urban areas. It provides immediate financial benefits in terms of loss reduction and electricity theft minimization.

ACKNOWLEDGEMENTS

Authors are thankful to Mehran University of Engineering and Technology Jamshoro for providing necessary resources including PSS SINCAL simulation software. Cooperation of HESCO staff for survey is also acknowledged here.

REFERENCES:

Aguero, J. R. (2012) "Improving the efficiency of power distribution systems through technical and non-technical losses reduction." In IEEE PES Transmission and Distribution Conference and Exposition, Orlendo FL,1-8.

Amanulla B, S. Chakrabarti, S. N Singh, (2012), “Reconfiguration of power distribution systems considering reliability and power loss”. IEEE Transactions on Power Delivery, 27(2), 918-26.

Capitanescu F, L. F Ochoa, H. Margossian, (2015), “Assessing the potential of network reconfiguration to improve distributed generation hosting capacity in active distribution systems”, IEEE Transactions on Power Systems, 30(1), 346-356.

Dai W., W. X. Sheng, K. Y. Liu, Y. Sheng, Z. J. Ye, (2015), “A Novel Reconfiguration Method in Smart Distribution Grid Considering Interval Data and Distributed Generation”, In International Conference on Computer Information Systems and Industrial Applications, Atlantis,

Farhana, U., N. K. Afridi, A. A. Sahito, (2013). “Critical analysis of capacitors as a potential solution to achieve optimum level voltage regulation in HESCO network”, in International Conference on Technological Advances in Electrical, Electronics and Computer Engineering (TAEECE 2013), Turkey, 488-497.

Farahani V, B. Vahidi, H. A. Abyaneh (2012), “Reconfiguration and capacitor placement simultaneously for energy loss reduction based on an improved reconfiguration method” IEEE Transactions on Power Systems, 27(2). 587-595.

Imran A. M., M. Kowsalya, D. P. Kothari, (2014), “A novel integration technique for optimal network reconfiguration and distributed generation placement in power distribution networks”, International Journal of Electrical Power and Energy Systems. V.63, 461-472.

Nguyen T. T, A. V. Truong, (2015), “Distribution network reconfiguration for power loss minimization and voltage profile improvement using cuckoo search algorithm”, International Journal of Electrical Power and Energy Systems, V. 68, 233-242.

Rao R. S., K. Ravindra, K. Satish, S.V. Narasimham, (2013) “Power loss minimization in distribution system using network reconfiguration in the presence of distributed generation”, IEEE Transactions on Power Systems, 28(1), 317-325.

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

Sahito, A. A., Z. A. Memon, P. H. Shaikh, S.A. Memon, (2015), ”Unbalanced Loading; An Overlooked Contributor to Power Losses in HESCO”, Sindh University Research Journal (Sci. Ser.), 47(4), 779-782.

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 and Electronic Systems (VITAE), Aalborg Denmark, 1-5.