Pakistan Journal of Science, 71 (4 Suppl.): 2019, Page 84-90
ISSN: 2411-0930

IMPACT OF DGs PLACEMENT ON VARIOUS FEEDERS IN DISTRIBUTION NETWORK FOR POWER LOSS REDUCTION AND VOLTAGE STABILITY

A. Javed[1,*], S. Raza[1], S. Iqbal[2], N. Nawaz[1], A. Javaid[1] and W.Q. Awan[1]

[1]Department of Electrical Engineering, NFC Institute of Engineering & Technology, Multan, Pakistan
[2]Department of Electrical Engineering, Information Technology Superior College, Lahore, Pakistan
[*]Corresponding author's E-mail: adnanjaved253@gmail.com

ABSTRACT: Nowadays, with the growing demand of electricity, the grid integration of renewable energy sources (RES) is highly required to reduce the dependency on fossil fuels, which will help to diminish the gas emissions and the level of carbon impression in power generation. The dependency on renewable energy resources is environment friendly for energy production therefore, the inverter-based photovoltaic (PV) generators are taken into deliberation as one of the reliable solutions, which is pollution free and effectively introduced to residential locations. The size, location and type of integrated DGs influences the performance and behavior of the system. The optimal allocation of distributed generators (DGs) has significantly impact on voltage profile and power loss of the grid due to load flow changes in the distribution network. In power system, technical and economical index divulges to the energy loss rate. This paper presents the optimal allocation of DGs at different locations by applying "Radial load-flow analysis" algorithm which will analyze the active power flow for low loss feeder and high loss feeder in MEPCO radial distribution network. Also, impact on voltage stability and power loss reduction of low loss feeder and high loss feeder by varying the DG's positions at various points in all respect of the feeder are examined. Along with this, cost of electricity and energy losses (KWH) additionally examine in this study. SYNERGEE (5.0) Electric GIS-mapping based software is used for the Simulation of this study.

Keywords: Distributed generator, Power losses, Voltage drops, Optimization, Units consumption

INTRODUCTION

Energy has become the most basic need for all living-beings on the earth. It can neither be created, nor devastated yet might be changed from one form to another form. In start of twentieth century; world economy has grown so quickly that mankind is confronting a few significant issues that incorporate population enhancement and environmental deterioration. Smooth and efficient energy is a significant factor to sort out these issues. Western countries are inspired by independent energy sources and the word, distributed generator was developed. Distributed generator designated as DG, has greater significance on upgrading system, empowering protection and going towards economic advancement. The central power plant system isn't fitted for providing reliable and, cost effective power to remote zone customers. They're not plentiful to meet the enhancing power consumption. In this manner, the power system is relying upon appropriated distributed generators (DGs) innovation for the development of power system reliability, energy efficiency and voltage stability.

Nowadays, power distribution network is shifting into the smart grids to ensure the intelligent network. The guideline key is; by integration of power the conventional systems are moving towards smart distribution networks. By the integration of power system various factors arises: avoid high power generation, execution of environmental change because of carbon decrease, voltage stability and power flow analysis. Also, by integration of renewable DGs in distribution network issue emerges due to technical, environmental and economic concerns. Likewise, there might be a worldwide examination that integration of RESs (Renewable Energy Sources) are in expanding demand phase for power to diminish the degree of carbon impression in power generation (Farsadi *et al.*, 2016).

Various countries are switching towards integration of renewable energy sources (RESs). This will decrease the power generation by means of conventional sources (gas, oil and coal) that is giving around 80% of energy (Santos *et al.*, 2017). Indeed, despite the fact that trend of renewable energy sources (RESs) is increasing, (especially geothermal, wind and solar) this rate in the energy is exceptionally less, which is about 0.5%. Different countries have defined their objectives to diminish the reliance on petroleum derivatives because of its disadvantages and expanding the renewable energy sources (RESs) integration to their networks. Alongside this, it will diminish the greenhouse gasses which transmits from the conventional assets.

In power system, power loss rate depends upon economic and technical index. By the interconnection of DGs into the grid system, the power flow attributes vary, and it will effect on the system loss. Likewise, with respect to the inconvenience of increase in load demand with time, there is necessary to update the substation systems by extra electrical tools which need a lot of time and cost, alternatively it can be sort out by connecting DGs into the system. Moreover, in electrical system distributed generators units are utilizing which consists of photovoltaic (PV) techniques which is free from gas discharges because of environment friendly features and can be easily introduced to residential areas. Along these lines, when DG is installed through grid PV is joined with inverters that will convert alternating current into direct current and give DC output power. Thus, the PVs utilized will be inverter-based distributed generators. The impact will occur on system line flows and voltage profile when the parameters and location of DGs will be changed. However, load-flow analysis will tell that what affect occurs on power flow and voltage stability by the integration of DGs in the distribution system.

Power system depends upon four factors which are linked with busses i.e. voltages, phase angle, real power and magnitude of reactive power. In these two factors will be known and other two factors will be unknown. There are major two main losses in the system i.e., transformer and line losses. Real power loss relies on the line length and resistance, it deals with line loss and called thermal loss (Farsadi *et al.*, 2016) and (Gameel, 2013). This paper analysis the optimal allocation of DGs at different locations by using "Radial load-flow analysis" algorithm in MEPCO radial distribution network for low loss feeder and high loss feeder. Furthermore, impact occurs on voltage profile and power loss reduction by varying the DGs location on low loss feeder and high loss feeder is also investigated. In addition, cost of electricity and energy loss (KWH) is also consider in this analysis. SYNERGEE (5.0) Electric GIS-mapping based software is used for the Simulation of this study.

Although, researchers are intriguing towards finding the optimal location and size of the distributed generators. In (Qing *et al.*, 2013) and (Jubran *et al.*, 2016) different methodologies are utilized to examine what affect will occur by the interconnection of DGs in the distribution network. Particularly these methodologies are utilized to figure rules for the integration of DGs in distribution network (Zubo *et al.*, 2017). The fundamental issue emerges by the interconnection of DGs are optimal placement, DG capacity and network topology; in the light of the fact that, each bus consists of various optimal level of DGs integration; in some other case, system loss can likewise enhance (Das and Kumar, 2018).

Distributed Generation DG: Technologies and types: DGs are divided into three sorts of advancements, for example, storage technology, renewable technology and non-renewable technology. Renewable technology consists of wind, solar, biomass, geothermal, hydro power and tidal. Non-renewable technology comprises of combustion turbine, micro-turbine, reciprocating engines and gasoline turbine. Storage technology contains flywheels, pumped storage, compressed air energy storage (CAES) and batteries. Every technology has its own importance. Moreover, various modes are utilized to fulfill the load demand of consumers by the deployment of these technologies.

Benefits of DGs: Various objectives might be accomplished through the interconnection of DGs in the distribution system. These advantages are additionally categorized into technical, economic and environmental benefits. Technical benefits contain, by the interconnection of DGs at optimal location system losses are decreased, by connecting DGs increase in voltage stability, power quality is increased, system reliability and security is improved, remote area power supply and overall power efficiency is improved (Ismail *et al.*, 2015). Economic benefits comprise of operation and maintenance cost is very less, system productivity is improved by involving different kind of resources, medical services cost is reduced as economic impact is diminished, fuel cost is diminished by the advancement in efficiency, cost related to non-renewable technology is diminished in this technology, investment risk is decreased. Environmental benefits composed of environmental contamination is decreased, impact on global warming is decreased.

Issues in DGs: These days' organization of DGs are managing with various issues. Major issues are regulatory, environmental, technical and commercial. Settling them will bring about greater use of Distributed Generators (Santos *et al.*, 2017; Ismail *et al.*, 2015) and (Muruganantham *et al.*, 2017). Figure1 shows the following issues. The objective of this paper is to analyze the power and voltage losses in real-time working feeders and search for an optimal location of DG to minimize these losses. This analysis is carried out using radial distribution system on SYNERGEE simulation tool by specifying the nodes and busses.

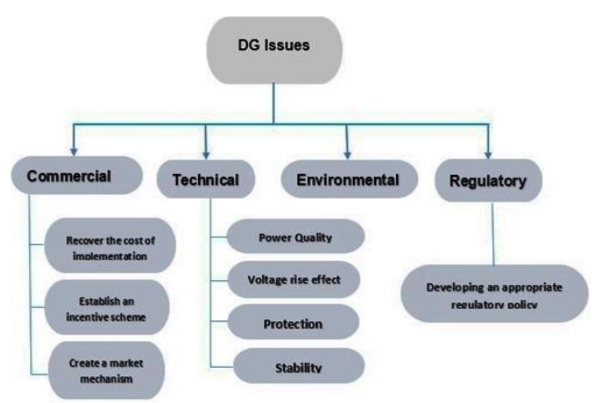


Figure-1: Issues in Distributed Generators.

Total active or reactive power loss can be determined as:

$$P_{loss} = \sum_{i=1}^{n_{br}} I_i^2 R_i \quad (1)$$

$$Q_{loss} = \sum_{i=1}^{n_{br}} I_i^2 X_i \quad (2)$$

where: I, R and X represents the "magnitude of current, resistance and reactance" of branch respectively, n_{br} the total number of branches in the feeder.

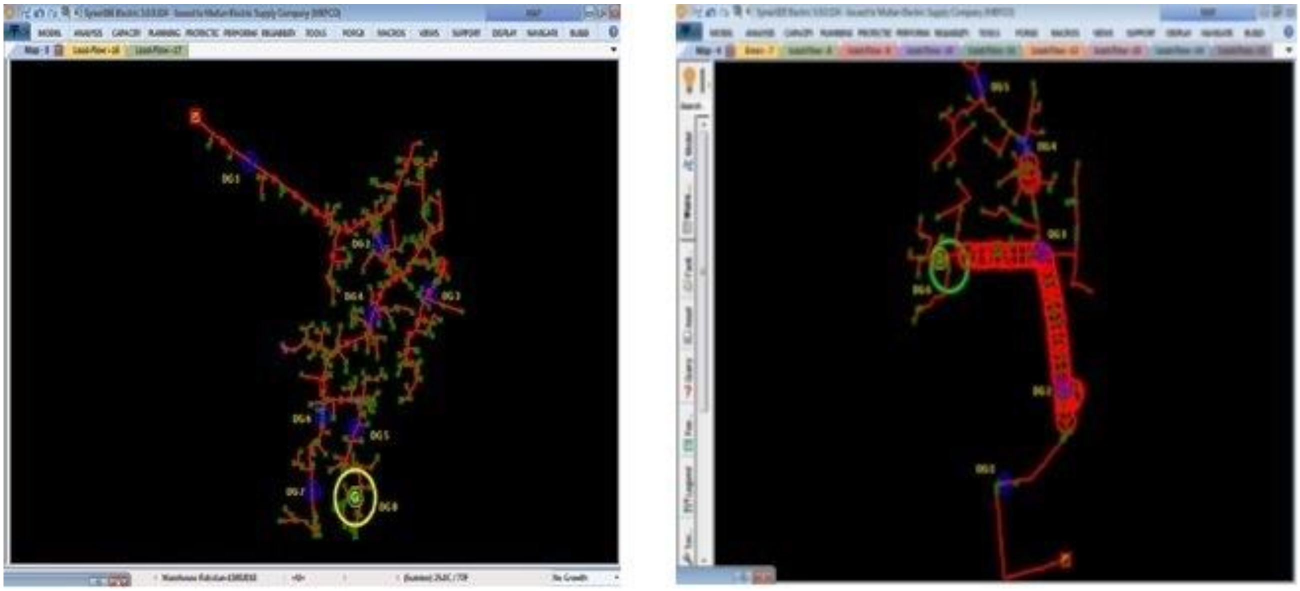


Figure-2: Real time feeders modeling. (a) High loss Feeder Model. (b) Low loss Feeder Model.

MATERIALS AND METHODS

Many countries are facing challenges for various losses due to the transmission and distribution system. As Pakistan is facing an economic and electricity shortages issues, then these losses became a significant challenge for country and arises a power-cut time. Here, in this study, we consider a distribution system to analyze the pattern in voltages drops and power losses. Two types of feeders having low and high losses are considered for this investigation. These feeders are installed in Multan division, Pakistan. The modeled diagram of high loss feeder and low loss feeder, which is known as "Mochi-Wala feeder" and "High_Court feeder" that are shown in 2. (a) and 2. (b) respectively.

Load flow calculation is used for the determination of losses, current flow, line load and voltage drops. For rural areas LF-0.4 and for urban areas LF= 0.6 taken as the standard for distribution network in Pakistan. Load flow analysis can be performed either for selected feeder or substations. There are no restrictions on assortment of segments that might be involved in load-flow analysis. Generators as contemplated as negative consistent power stacks through the analysis of network load-flow regardless of set up. Although, they are induction or synchronous machines, they are seen as "PQ machines" in system load-flow. The DGs are installed in the center of the section with an artificial bus and rating are adjusted from "0KW to 10MW". They can be connected at the right of customers' end, decrease in main power source or they will be related with the couple of elements at the distribution system through a fixed transformer and tap unit that isn't a portion of customer end. DGs assets encased an immense sort of advancement and primary resources of energy, which includes PV (Photovoltaic) technology, where PV panels produces direct current as an output from the solar radiation. However, power optimizer of photovoltaic panels is utilized to generate DC which is required to transmit output power to the distribution network. The considered algorithm, which is used in this paper, is contained explicit strategies for handling "Kirchhoff's law" and assure that device models and loads are analyzed. It incorporates the most precise and robust by-phase load-flow technique. The fundamental focal point of this paper is that it consists of two feeders in which one feeder is "Urban (Low Loss) feeder" approximately "4.85MW" and second is "Rural (High Loss) feeder" approximately "4.57MW" of Multan Electric Power company (MEPCO) which is considered as distribution company of energy in Pakistan. The load of both feeders is same which is about "300A". The reason for this study is that, what affect occurs throughout the feeder parameters by the allocation of DGs at various points and observed that which point is optimal at which voltage drop and power losses is minimum and that will be the optimal location of distributed generator.

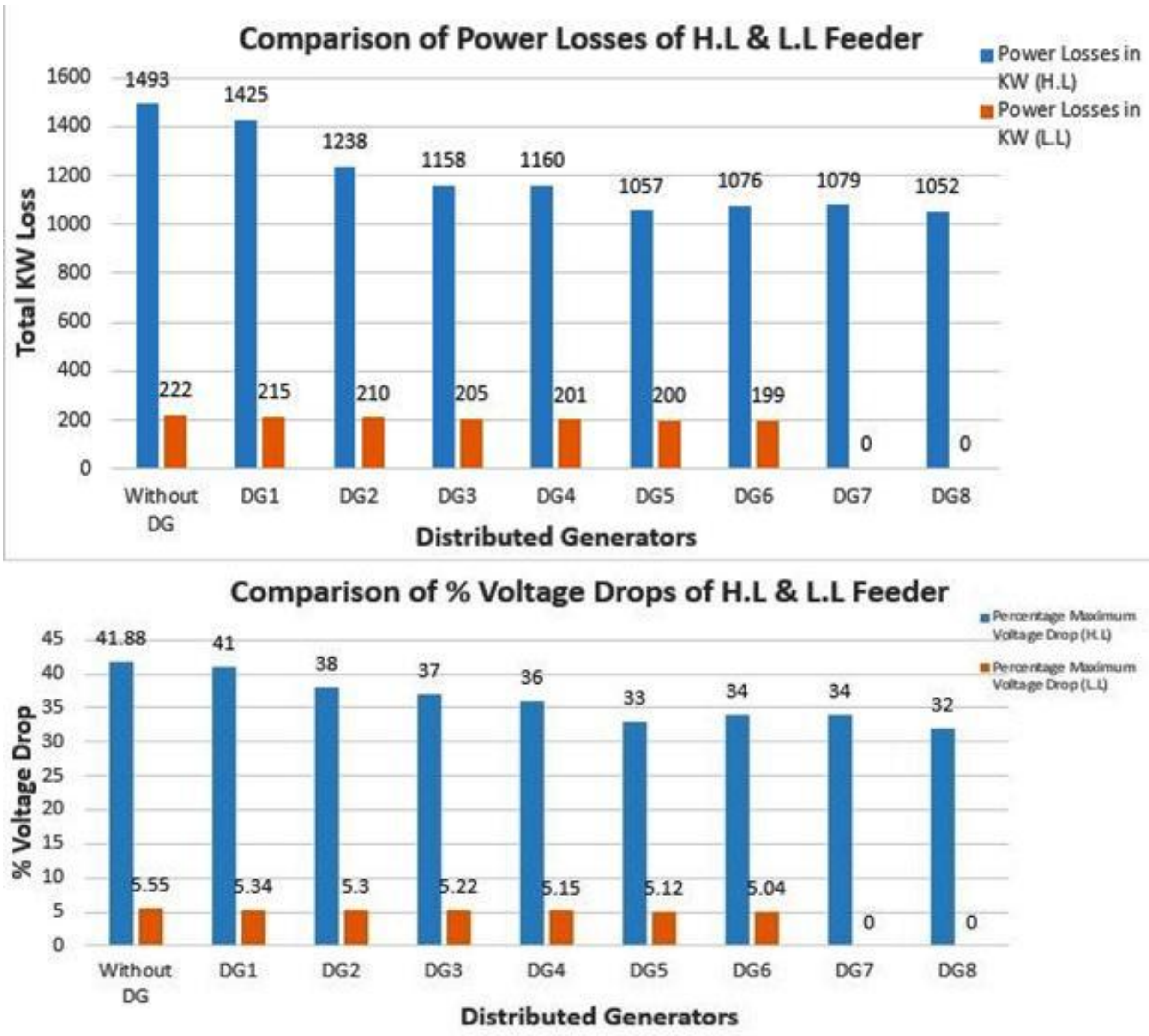
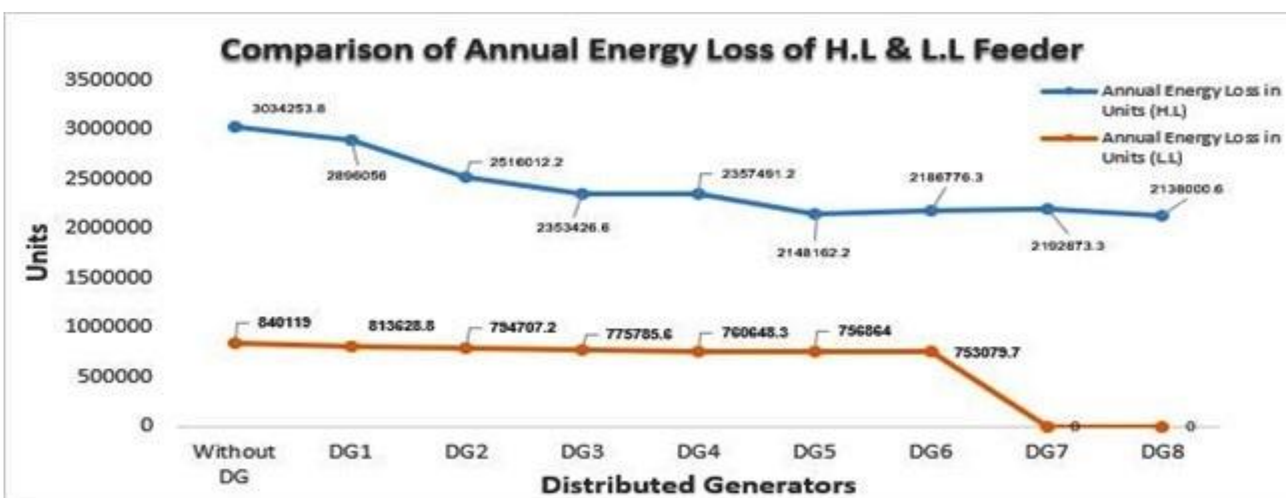


Figure 3: Comparison between various feeders. (a) Power losses comparison. (b) Voltage losses comparison.



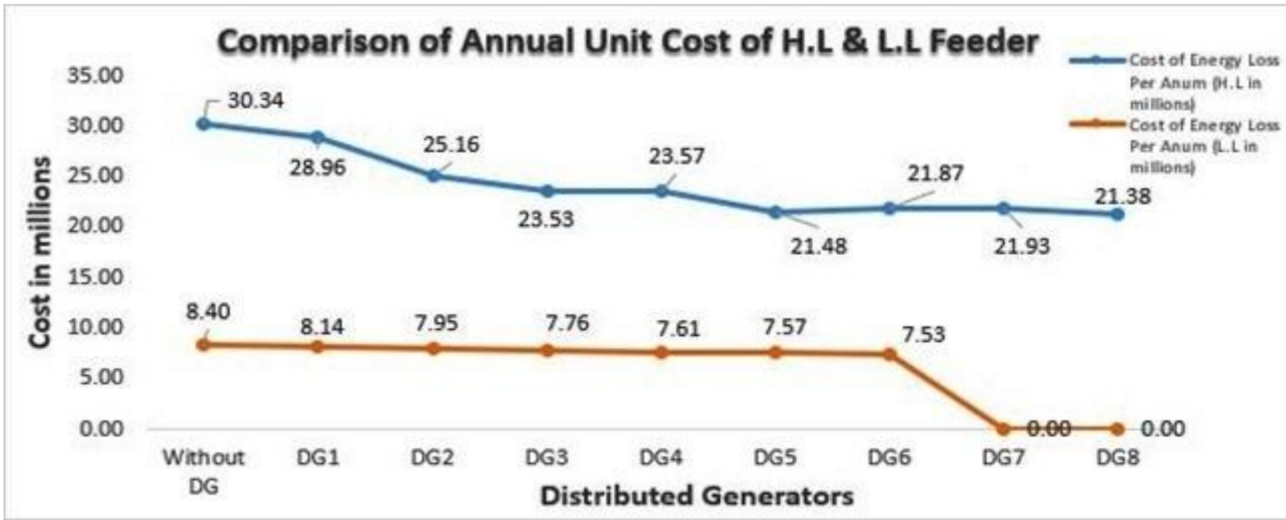


Figure 4: Comparison between various feeders. (a) Energy losses. (b) Unit Cost.

RESULTS AND DISCUSSION

The low loss feeder has a power factor of 0.85 with 18 KM length. Real power of this low loss feeder is "4.85 MW" with 300A. Principle feeder need to infuse the total power to the network that must be indistinguishable from the whole of all load powers which consists of transformer losses and line losses. In this analysis, there are "Six DGs" interconnected at various locations by "Radial Load-flow analysis" algorithm and determined the overall feeder parameters with and without interconnection of DGs to find out the optimal location, where voltage drops and power losses should be least throughout the feeder.

With no DG interconnection, the overall line and transformer losses are calculated as 222KW. The percentage losses of power and voltage are taken as "4.57%" and "5.55%" respectively. When DG is interconnected, about "350KW" rooftop sun powered, the main power source is distributed between distributed generator and feeder. Although each zone of DGs, where line losses and voltage stability are analyzed through a load-flow analysis. The simulation outcome of power flow analysis is utilized for the determination of power losses, which shows the electricity conveyed to each bus. The main feeder generator referred as a "Swing bus", where "Swing bus" alludes to a reference bus having steady voltage for magnitude and angle, "PQ load buses" are utilized. The overall results of percentage voltage drop and active power loss of the feeder, along with annual energy loss (KWH) and annual cost for each case of connecting DGs at different locations.

The results illustrated that; by the nterconnection of DGs at various locations will impact on voltage profile as well as power losses. Here we can conclude that at DG 6 location there is maximum impact occurs throughout the feeder by the interconnection of DG, however there occurs minimum percentage voltage drop and power loss that is about "5.04%" and "199 KW" respectively, which is very least in contrasted with the allocation of other DGs. Consequently, it is analyzed that the location of DG 6 will be optimal because there are least transformer and line losses for real powers. The comparison of with the interconnection of DG 6 and with no DG clearly shows that there is about "0.51%" voltage drops and about "23 KW" power loss is improved. Whereas, "87040" units of energy and approximate "0.87 million" are saved per annum.

Impact of DG allocations on High Loss Feeder: The high loss feeder has a power factor of 0.80 with 149 KM length. Real power of this high loss feeder is "4.57 MW" with 300A. Principle feeder need to infuse the total power to the network that must be indistinguishable from the whole of all load powers which consists of transformer losses and line losses. In this analysis, there are "Eight DGs" interconnected at various locations by "Radial Load-flow analysis" algorithm and determined the overall feeder parameters with and without interconnection of DGs to find out the optimal location, where voltage drops, and power losses should be least throughout the feeder.

With no DG interconnection, the overall line and transformer losses are calculated as 1493 KW. The percentage losses of power and voltages are taken as "32.75%" and "41.8%" respectively. When DG is interconnected, about "350KW" rooftop sun powered, the main power source is distributed between distributed generator and feeder. Although each zone of DGs, where line losses and voltage stability are analyzed through a load-flow analysis. The simulation outcome of power flow analysis is utilized for the determination of power losses, which shows the electricity conveyed to each bus. The main feeder generator referred as a "Swing bus", where "Swing bus" alludes to a reference bus having steady voltage for magnitude and angle, "PQ load buses" are utilized. The overall results of percentage voltage drop and active power loss of the feeder, along with annual energy loss (KWH) and annual cost for each case of connecting DGs at different locations are shown in given Table II.

The results illustrated that; by the interconnection of DGs at various locations will impact on voltage profile as well as power losses. Here we can conclude that at DG 8 location there is maximum impact occurs throughout the feeder by the interconnection of DG, however there occurs minimum percentage voltage drop and power loss that is about "32%" and "1052KW" respectively, which is very least in contrasted with the allocation of other DGs. Consequently, it is analyzed that the location of DG 8 will be optimal because there are least transformer and line losses for real powers. The comparison of with the interconnection of DG 8 and with no DG clearly shows that there is about "9.88%" voltage drops and about "441 KW" power loss is improved. Whereas, "896,253.2" units of energy and approximate "8.96 million" are saved per annum.

Comparative analysis of DG allocations on High Loss and Low Loss Feeder: SYNERGEE software is used for the comparative analysis of active power flow in MEPCO radial distribution system for low loss feeder and high loss feeder. The load of both feeders is same for comparison because power losses depends upon load. Moreover, the minimum and maximum percentage voltage drop, and power losses are analyzed by the interconnection of DGs. Fig 3. (a) express that the improvement of power loss occurs by the optimal allocation of DGs is about 23 KW in low loss and 441 KW in high loss feeder respectively. Fig 3. (b) express that the improvement of percentage voltage drop occurs by the optimal allocation of DGs is about 0.51% in low loss and 9.88% KW in high loss feeder respectively. Due to which Fig 4. (a) shows that the improvement of energy in terms of units (KWH) per annum occurs by the optimal allocation of DGs is about 87040 units in low loss and 896,253.2 in high loss feeder respectively. Also, Fig 4. (b) depicts that the improvement of energy results in the saving of cost per annum occurs by the optimal allocation of DGs is about 0.87 million in low loss and 8.96 million in high loss feeder respectively. Which is monetarily gainful for the distribution company and that is linked with government.

Conclusion: The grid integration of RES based DGs in an electrical power system can reduces the distribution network losses, which includes the system line losses and voltage profile. The overall analysis should be completed earlier than by the integration of distributed generation units to offer the suitable solution that bring about an adequate DGs integration. Moreover, optimal placement of DG has significant impact on technical and economic aspects throughout the feeder. The optimal allocation of DGs will reduce the system power losses and maximize the energy efficiency and profit for the distribution company. This paper has investigated in radial distribution system and analyzed the impact of integrated DGs at different locations for voltage stability and power losses. In this study, "Radial load-flow analysis" algorithm is utilized for the optimal allocation of distributed generators and analyzed that what impact will occur on high and low loss feeders. From the analysis, it is cleared that when no DG is interconnected to the feeder there is comparatively higher percentage voltage drop and power losses in comparison by connecting DGs in the feeder at optimal or any other location. The simulation results show that in low loss feeder (High_Court) the optimal location is "DG 6" and in high loss feeder (Mochi-Wala) "DG 8" is the optimal location due to minimum drops in power and voltages. In this paper, it is clearly observed that there is significant affect occurs on the overall feeder parameters by the interconnection of DGs on high loss feeder and low loss feeder. Moreover, the simulation results of this study clearly show that there is least improvement occurs in low loss feeder (High_Court). In this paper, it is analyzed that maximum improvement will occurs on high loss feeder (Mochi-Wala) because there are maximum losses throughout the feeder and by connecting DG maximum impact will occur on that location where voltage drop and power loss is maximum and that will be the optimal location of DG. The optimal location will be efficient because there is minimum voltage drop and power losses present.

REFERENCES

Das, B. and A. Kumar (2018). A NLP approach to optimally size an energy storage system for proper utilization of renewable energy sources. *Procedia Computer Science*, *125*, 483-491.

Farsadi, M., T. Sattarpur and A. Yazdaninejadi (2016). Simultaneously Optimal Placement and Operation Scheduling of BESSs and DGs in Distribution Networks in order to minimizing net present value related to power losses. *Istanbul University-Journal of Electrical & Electronics Engineering*, *16*(2), 2081-2089.

Gameel, K.M. (2013). Optimal locations of distributed generations in electrical power distribution system. In *2013 7th IEEE GCC Conference and Exhibition (GCC)* (pp. 577-582).

Ismail, N., S. Favuzza, M.G. Ippolito and F. Massaro (2015). Effect of voltage deviations on power distribution losses in presence of dg technology. In *2015 International Conference on Renewable*

Energy Research and Applications (ICRERA) (pp. 766-771).

Jubran, M.K., S. Favuzza and F. Massaro (2016). Reassessment of voltage stability for distribution networks in presence of DG. In *2016 IEEE 16th International Conference on Environment and Electrical Engineering (EEEIC)* (pp. 1-5).

Muruganantham, B., R. Gnanadass and N. P. Padhy (2017). Challenges with renewable energy sources and storage in practical distribution systems. *Renewable and Sustainable Energy Reviews*, *73*, 125-134.

Qing, Z., Y. Nanhua, Z. Xiaoping, Y. You and D. Liu (2013). Optimal siting & sizing of battery energy storage system in active distribution network. In *IEEE PES ISGT Europe 2013* (pp. 1-5).

Santos, S.F., D.Z. Fitiwi, M.R. Cruz, C.M. Cabrita and J.P. Catalão (2017). Impacts of optimal energy storage deployment and network reconfiguration on renewable integration level in distribution systems. *Applied energy*, *185*, 44-55.

Zubo, R.H., G. Mokryani, H.S. Rajamani, J. Aghaei, T. Niknam and P. Pillai (2017). Operation and planning of distribution networks with integration of renewable distributed generators considering uncertainties: A review. *Renewable and Sustainable Energy Reviews, 72,* 1177-1198.