Reduction of Power losses in Distribution System using Distributed Generation through Net Metering

[1] **Bilawal Q. Memon,** [2] **Anwar A. Memon,** [3] **Shafi M. Jiskani,** [4] **Noor Nabi Shaikh,** [5] **M. Rashid Memon**

[1]Student M.E. (Electrical Power), [2, 3, 4, 5]Assistant Professor

[1]Institute of Information and Communication Technologies, [2, 3, 4, 5]Department of Electrical Engineering,
Mehran University of Engineering & Technology, Jamshoro, Pakistan
Email – bilawalmemon43@gmail.com

Abstract: *Decreased losses in distribution systems have been triggered due to rising electricity supply costs, fuel shortages with ever-increasing costs of generating more energy and global warming problems. These initiatives have been presented to utilities in the form of incentives and fines. Distributed Generators (DGs) are currently widely used to reduce power losses and voltage fluctuations in distribution networks. The best results can be achieved by the optimal location and size of the DG. This study is conducted using Synergee Electric / adept as a modelling tool in an energy distribution system. The proposed method of reducing technological losses adds new equipment and Improves energy distribution system performance by reconfiguring the network to optimize energy flow. For experimental models the 11kV Khatan radial distribution feeder is used to impact the voltage profile. The node voltages of the existing network were measured below the lower acceptable limit of-5% of the nominal voltage. 1 MW DG Unit is proposed to meet local requirements. The findings of the simulation of the proposed network show a significant increase in the H.T and L.T node voltages. Node voltages are increased so that they are within an acceptable limit. This method has been implemented in the context of an example of a real distribution system of MEPCO 11 kV feeder and the effects of distributed generation through net metering in the distribution system. When a proper plan is drawn up, the transformer installation and the DG are properly implemented and the overload problem will be resolved by promoting Net-Metering together with the distributed generation.*

Key Words: *Distributed Generation, Energy Loss Reduction, Geographic information system, High Tension, Kilo Volt, Low Tension, Multan Electric Power Company, Pole Mounted Transformer.*

1. INTRODUCTION:

The overall effect of energy losses in the system is to reduce the amount of energy available to consumers. As such, appropriate action should be taken to minimize the energy losses [1]. Electrical system losses will range from 3% to 6%. It is not more than 10% in developed countries, but the level of active energy losses in developing countries is about 20%, and utilities are currently interested in reducing it to make it more competitive, as electricity prices are correlated with system losses in deregulated markets [2]. Pakistan power sector is facing energy crises mainly caused by generation demand gap. New power generation capacities are proposed to meet generation demand. Transmission and distribution network expansions are planned. Distributed Generation (DG) is small generation employing renewable energy resources and directly connected to distribution system [3]. Technical losses are losses in the electrical system due to impedance, current, line length and auxiliary sources. The sources of technical losses may depend directly on the configuration of the network, the network equipment and the burden on consumers of the distribution network. Network investments are used to improve the quality of the system, as an outcome of which the distribution system is extended and the size of the technical losses during distribution is determined. Technical losses and their reduction are the main concern for the supply of electricity [4]. MEPCO power supplies include 11kV electricity line which crosses the load zone. Installed in an appropriate place, the distribution transformer reduces the voltage to the operational level (230/415 V). The transformer's secondary component (LT), which connects the customer and the public network via a distribution cable, moves across the public services sector [5]. Non-technical losses result in high operating costs and significant losses in public service revenues. The technical losses consist of normal losses in the power supply network systems connected with heat dissipation, transmission and distribution cables, transformers, and measuring devices. This leads to significant energy costs. Because system failure represents significant costs for public services, customers. Its assessment and reduction were described as an area of mutual interest [6]. Voltage below minimum acceptable level or higher. Consequently, people will face risks, poor quality and high energy costs that are unacceptable to the industry. To increase the efficiency of the transmission network, technical losses must be assessed and minimized. Ensure reliability and efficiency for end users with high quality electricity [7].

Table 1. Technical Loss Evaluation for Distribution Network of MEPCO FY-2018-2019
(As per 3RD Party Interim Report)

Sr. No.	Description	%Age Loss
1	HT Network	9.7
2	LT Network	2.45
3	Service main	0.22
Total Distribution Loss		**12.37**

It's expected to attract results by using DG units to reduce real energy losses. A better understanding of electric energy flows in transmission lines explores energy losses along transmission lines. The use of computer software gives an idea of the main problems in electrical energy transmission. Minimizing power line losses using optimization method provides a compact solution to the main problem that occurs during transmission of energy [8].

Table 2. Transmission and Distribution Line Losses (T&D) MEPCO

F. YEAR	Units Purchased	Units Sold	Units Lost	% Age Lost	NEPRATa rget	% Age Growth in	
						Unit Purchased	Unit Sold
2010-11	12448.23	10188.51	2259.72	18.2	15.0	1.71	2.75
2011-12	12440.88	10218.23	2222.65	17.9	15.0	-0.06	0.29
2012-13	11947.01	9913.09	2033.92	17.0	15.0	-3.97	-2.99
2013-14	13858.95	11437.25	2421.69	17.5	15.0	16.00	15.38
2014-15	14061.77	11711.25	2350.52	16.7	15.0	1.46	2.40
2015-16	14770.25	12340.67	2429.59	16.4	15.0	5.04	5.37
2016-17	15951.42	13253.18	2698.24	16.9	15.0	8.00	7.39
2017-18	19005.97	15853.21	3152.76	16.6	15.0	19.15	19.62
2018-19	19366.66	16309.60	3057.06	15.8	15.0	1.90	2.88

Voltage analysis in order to analyze HT & LT bus voltages and power loss of OPH-II network (11kV & 400V) feeder of (HESCO). (PSS SINCAL) comparative analysis of HT & LT bus voltage before and after installation of capacitor were performed. It was concluded that lower power losses and better voltage rating was offered by capacitor in comparison with existing network [9]. Simple and understandable technique for determining appropriate allocation and sizing of Distribution Generation (DG) with DSTATCOM in radial distribution network, to improve voltage profile. In order to validate results power stability index is used and proposed system was compared with IEEE 34 BUS and 69 BUS existing system [10]. The optimal rating of Distribution Generation (DG) for bettering the voltage profile on distribution feeder and decreasing the power losses suggested probabilistic approach with the conclusion that multiple distribution generation placements reduce feeder loss as compared to the placement of single distribution Generation [11]. Conducted sensitivity analysis to determine most optimal size and location of Distribution Generation (DG) for reducing I2R losses and improving stability of voltage in DISCOS. In this paper the suggested techniques were analyzed on IEEE 37 bus system 11kV distribution feeder by using electrical transient analysis (ETAP) software [12]. The power plant generated energy reaches the end user through complex and extensive networks such as cables, transformers, overhead lines and other equipment. In fact, the energy generated by the power plant does not match the units consumed by the end user because the transmission and distribution networks have a percentage of losses. Hyderabad Electricity Supply Company (HESCO) is the power distribution utility having power losses in excess of 25% as compared to utilities in developed countries having 3% [13]. Distributed Generation (DG) refers to electricity generation near the point of consumption [14]. It eliminates complex transmission network between generation and utilization.

DGs normally use renewable energy resources for power generation and are considered as environmental friendly generation. Alteration of power system results in variations of voltage drops, stability, reliability and power losses [15]. Analyzed impacts of DG for voltage regulation and concluded settings of voltage regulating equipment are changed with DG interconnections [16]. Simulation analyzes the 11kV radial power distributor to examine the results of several DG technologies in terms of reducing power losses. Because of its ability to introduce reactive power, wind generation using a synchronous generator results in maximum reduction of power losses. An induction generator requires reactive energy from the network and results in minimal loss of energy. Solar cells produce only active energy and reduce the energy loss moderately [17].

The main problem is the calculation of real power loss during transmission of power over the line in the transmission network. There is a high level of technical loss to MEPCO distribution system. A drop in voltage led to a low voltage at the terminals for consumption. Consumers receive 200 or less voltage. Currently, shifting the demand on an overwhelmed power network / system in a low power network / installation will be a big problem for public services to improving the voltage profile and reducing MEPCO technical losses. It is important to analyze the voltage drops and energy losses of the 11kV power supplies with high losses, end consumers of lengthy 11kV feeder face voltage regulation issues. To tackle high losses of poorly efficient system, Distribution companies schedule vast load shedding hours.

2. STUDY OBJECTIVES:

To develop a new approach for measuring and reducing technical losses in the MEPCO Khatan 11kV feeder and can also be used in the DG.

- Analysing and reducing losses through distributed generation on 11kV khatan feeder of MEPCO.
- Resolving the problem of poor voltage by pointing feasible location of DG via simulating 11kV khatan feeder Synergee Electric software.
- Promoting Net-Metering along with DG.

3. METHODOLOGY:

- Collection of data for selected distribution feeder of MEPCO through field visits.
- Modelling of collected data on Synergee Electric software Simulation of existing feeder network to observe the extent of voltage profile problem.
- Simulation of network with DG interconnected at location.
- Comparison of results and observing the effects of DG interconnection.

4. ANALYSIS:

The 11kV feeder HT side and LT side are exactly based on the actual data gathered, and the simulation is working. The results are compared and loss differences for the next 11kV khatan feeder are presented. To observe technical losses the feeder was surveyed and simulated using Synergee Electric software. It focuses on improving the radial distribution feeder voltage profile through DG interconnection. One of the 11kV power supplies of the MEPCO network is selected for analysis. Actual network data for selected feeder is used for simulation and the results are analyzed for bus voltages of the existing system. One DG unit of 1 MW are suggested at physically viable location and the modified network is simulated to monitor the improvement of bus voltages.

11kV khatan feeder of MEPCO is selected for this research work. Supplies residential, commercial and pumping consumers of the khatan and surrounding areas. 8.650 MVA power capacity of distribution feeders is energized through 156 distribution transformers. (Fig. 1) shows node diagram of the selected khatan feeder. Actual data for high tension (H.T) and low tension (L.T) networks of the selected feeder were calculated through field visits in coordination with MEPCO staff. Collected data included length of different sections of H.T. lines, conductor type, transformer ratings, transformer impedance, L.T network lengths, conductor types and number of connections. Average loads are assumed for residential and commercial consumers. Loads of the pumping stations are selected by connected loads. One DG unit of 1 MW and 0.7 MVAR capacity are proposed at node 47. Network is modelled and simulated with and without DG unit to observe impact of DG on voltage profile of the selected feeder.

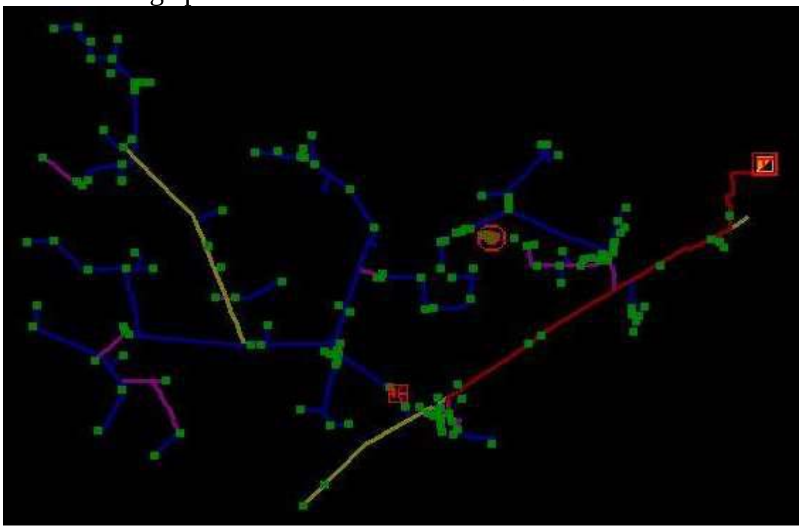

Fig. 1 11KV Khatan Feeder Node Diagram

5. RESULT:

Voltage comparison of the H.T nodes with and without proposed DG units. It is clearly shown that voltage of all the buses have improved considerably. Percentage increase in bus voltages for buses near the source is small as DG is installed away from these nodes. Appreciable increase is observed at node 47 and near to these nodes where DG is installed. Node voltage of last two buses 72 and 74 have increased from 10.03 kV to 10.81 kV indicating an increase of 0.78kV. All the bus voltages are now within acceptable lower limit of -5%. (Table 3) shows the total numbers and capacity of transformers are installed in 11kV Khatan feeder. Fig.2 shows the simulation results of 11KV Khatan feeder.

Table 3. Number of Transformers (KVA) installed in 11KV Khatan Feeder

T/F (KVA)	Quantity
10	2
15	5
25	69
50	56
100	18
200	2
400	3
630	1
Total	156

All the transformers have L.T terminal voltage within acceptable limit of -5%. Highest percentage rise of 10.70% is observed for transformer 61 located at node 48, which is located at the end of a branch circuit. DG proposed at node 47 is responsible for this rise in voltage shown (Table 5). Voltage comparison of the L.T terminals of 156 transformers. It is clear that node voltages have improved considerably.

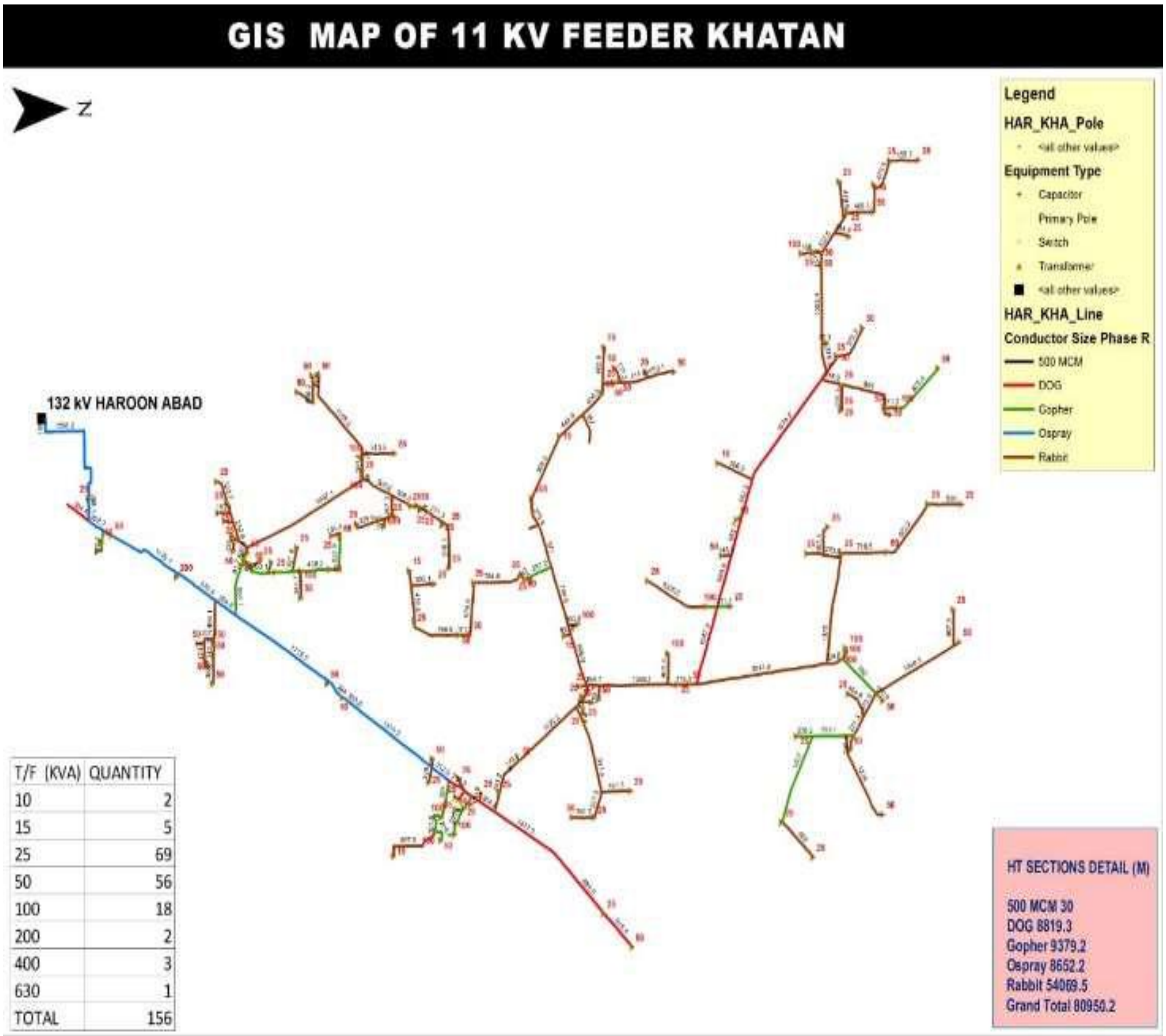

Fig 2. Simulation Results of 11KV Khatan Feeder

Table 4. HT Node Voltage Comparison

Node	Voltage Before DG (kV)	Voltage After DG (kV)	Rise in Voltage (kV)	Rise in Voltage (%)
40	10.03	10.82	0.79	7.87%
41	10.03	10.82	0.79	7.87%
42	10.07	10.83	0.76	7.55%
43	10.07	10.83	0.76	7.57%
44	10.06	10.83	0.77	7.63%
45	10.06	10.83	0.77	7.69%
46	10.05	10.83	0.78	7.73%
47	**10.05**	**10.83**	**0.78**	**7.78%**
48	10.04	10.82	0.78	7.79%
49	10.04	10.82	0.78	7.80%
50	10.03	10.82	0.78	7.80%
Continue				

Table 5. Load unbalance at transformers of 11kV Khatan feeder

Node	Voltage Before DG (V)	Voltage After DG (V)	Rise in Voltage (V)	Rise in Voltage (%)
47	366.12	396.58	30.46	8.32%
48	361.90	393.03	31.13	8.60%

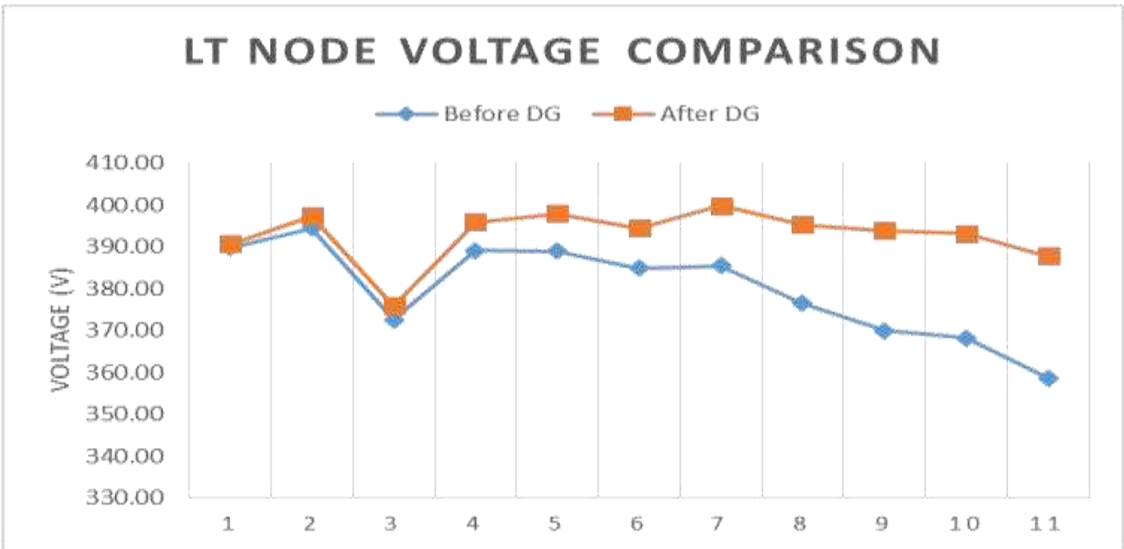

Fig. 3: LT Node Voltage Comparison

Table 6. Technical Losses of 11KV Khatan Feeder Before DG

Max Load (Amp)	Connected (KVA)	Length (km)	Voltage Drop (%)	AEL (%)	AEL (Mkwh)
160	8650	81.3	8	4.5	527,665
Total					**527,665**

Table 7. Technical Losses of 11KV Khatan Feeder After DG

Max Load (Amp)	Connected (KVA)	Length (km)	Voltage Drop (%)	AEL (%)	AEL (Mkwh)
134	8650	81.3	7.57	4.33	433,932
Total					433,932
Total Saving (KWH)					**93,733**

There are 156 PMT which supply / distribute electricity in the area. The technical losses vary between the transformers, depending on the length of the line and the connected loads before and after DG in (Fig 5). Transformers are mostly unloaded or lightly charged. After installing a DG, the total energy saving is 93733Mkwh.

Net-Metering is an incentive scheme for consumers of distributed generation-related energy systems typically using renewable energy sources. Net Metering attempts to optimize the use of the solar system installed in the territories of the customer by providing energy through the power grid during the hours when the network output meets the demand of the user.

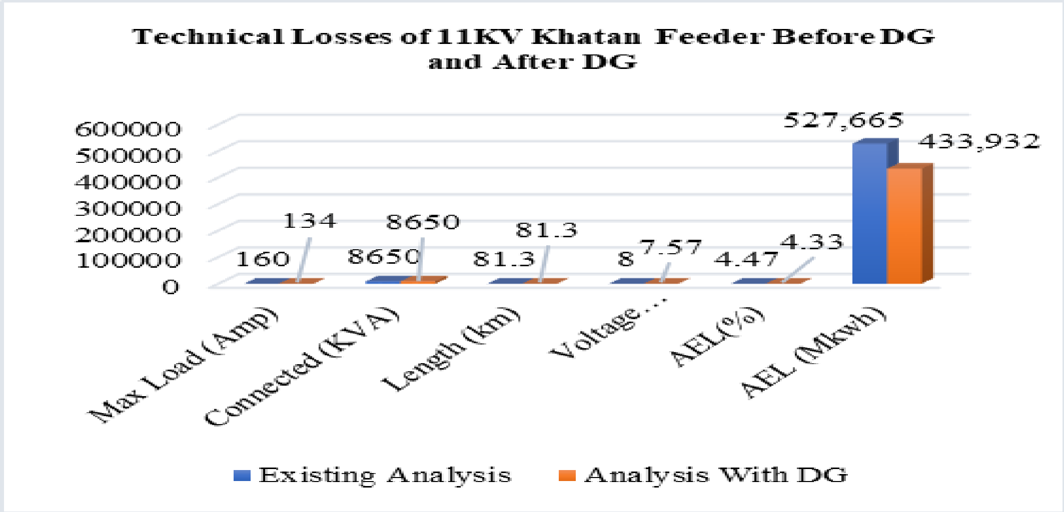

Fig 4. Technical Losses of 11KV Khatan Feeder Before and After DG

6. CONCLUSION:

In this paper, one of the 11 kV feeder supplying residential, commercial and pumping consumers in Khatan city is surveyed, modelled and simulated using Synergee Electric software to observe impacts of distributed generation on voltage profile. Node voltages below accepted level of -5% are observed through simulation results of existing network. Three DG units of 1MW and 0.7 MVAR are proposed at physically suitable location to meet load demands locally. Simulation results of modified network shows considerable improvement in voltages for all H.T and L.T nodes. Maximum of 8.87% voltage rise is observed for H.T nodes and 11.70% for L.T nodes. Voltages of all the buses are improved above lower acceptable limit of -5%. The total saving of energy is 93733Mkwh.

REFERENCES:

1. Mishra, V., Sharma, M.P., Vyas, B. and Ola, S.R., 2016, July. Power loss reduction of 11 kV feeder using capacitor banks to distribution transformers—a case study. In 2016 IEEE 1st International Conference on Power Electronics, Intelligent Control and Energy Systems (ICPEICES) (pp. 1-6). IEEE
2. Khattak, A., Khattak, A.U., Ullah, Z., Ali, K. and Yousaf, U., 2016. Analysis and Optimization of Radial Distribution Network Using GIS and GPS Techniques. International Journal of Computer Science and Information Security, 14(11), p.1.
3. Qureshi, S. A., and F. Mahmood. "Evaluation by implementation of distribution system planning for energy loss reduction." Pakistan Journal of Engineering and Applied Sciences (2016), 114-120.
4. Abdul-Wahhab, T.M. and Abdullah, O.A., 2016. SIMULATION AND CONTINGENCY ANALYSIS OF A DISTRIBUTED NETWORK IN IRAQ. Journal of Engineering and Sustainable Development, 20(4), pp.238-268.
5. Uqaili, M.A., Sahito, A.A., Halepoto, I.A., Memon, Z.A. and Dars, S.B., 2014, May. Impact of distributed generation on network short circuit level. In 2014 4th International Conference on Wireless Communications, Vehicular Technology, Information Theory and Aerospace & Electronic Systems (VITAE) (pp. 1-5). IEEE.
6. Ehsan, Ali, and Qiang Yang. "Optimal integration and planning of renewable distributed generation in the power distribution networks: A review of analytical techniques." Applied Energy 210 (2018): 44-59.
7. Muller, N., Roytelman, I., Medina, J., Ipakchi, A., Albuyeh, F., Rahimi, F., Hink, M. and Mokhtari, S., OPEN ACCESS Tech INTERNATIONAL Inc, 2017. Systems and methods for demand response and distributed energy resource management. U.S. Patent 9,847,644.

8. Pereira, Benvindo R., Geraldo R. Martins da Costa, Javier Contreras, and José R. Sanches Mantovani. "Optimal distributed generation and reactive power allocation in electrical distribution systems." IEEE Transactions on Sustainable Energy 7, no. 3 (2016): 975-984.
9. Sahito AA, MEMON Z, BURIRO G, MEMON S, JUMANI M, ANSARI M. Voltage Profile Improvement of Radial Feeder through Distributed Generation. Sindh University Research Journal-SURJ (Science Series). 2016 Sep 27;48(3).
10. Poornazaryan, Bahram, Peyman Karimyan, G. B. Gharehpetian, and Mehrdad Abedi. "Optimal allocation and sizing of DG units considering voltage stability, losses and load variations." International Journal of Electrical Power & Energy Systems 79 (2016): 42-52.
11. Sahito, Anwar Ali, Muhammad Azeem Arain, Irfan Ahmed Halepoto, Mansoor Ahmed Soomro, and Muhammad Juman Jumani. "Analyzing the Impacts of Wind Generation on Distribution System Performance." Indian Journal of Science and Technology 9 (2016): 47.
12. Sorrell, Steve. "Reducing energy demand: A review of issues, challenges and approaches." Renewable and Sustainable Energy Reviews 47 (2015): 74-82.
13. TUNIO, IRFAN A., AM SOOMRO, AH MEMON, and AS LARIK. "Distribution System Power Loss Segregation." Sindh University Research Journal-SURJ (Science Series) 50, no. 4 (2018): 547-550.
14. SAHITO A, KALHORO S, MAHAR M, MEMON M, LASHARI I. Distribution System Power Loss Reduction through Distributed Generation. Sindh University Research Journal-SURJ (Science Series). 2017 Mar 14;49(1).
15. Hung, Duong Quoc, Nadarajah Mithulananthan, and R. C. Bansal. "Analytical expressions for DG allocation in primary distribution networks." IEEE Transactions on energy conversion 25, no. 3 (2010): 814-820.
16. Ochoa, Luis F., and Gareth P. Harrison. "Minimizing energy losses: Optimal accommodation and smart operation of renewable distributed generation." IEEE Transactions on Power Systems 26, no. 1 (2010): 198-205.
17. Mari MA, Sahito AA, Bhayo MZ, Kalwar BA. Analyzing the Impacts of Solar PV Generation Integration on Radial Distribution Feeder. International Journal of Computer Science and Information Security (IJCSIS). 2018 Jan;16(1).