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Impact Analysis of Photovoltaic Penetration in Radial Distribution System : A Case Study of Bazar Feeder in Dhulabari DC

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Abstract

As more photovoltaic (PV) systems are added to distribution networks, they have a noticeable effect on voltage profiles and power losses. In this study, we examined PV integration in a 38-bus Bazar feeder at the Dhulabari distribution center using the DIgSILENT PowerFactory. We performed load-flow analyses at different PV penetration levels by placing the PV systems near the source (Bus 4), in the middle (Bus 19), and at the end (Bus 38) of the feeder. The results showed that at a low penetration level (10%), installing the PV system at the end bus (bus 38) reduced power losses the most. At higher penetration levels, placing the PV system in the middle (bus 19) was more effective for minimizing losses. With 40% PV penetration (2160 kW), the system had better voltage regulation and lower power losses. Installing PV at Bus 19 reduced active and reactive losses by 40% and 44.83%, respectively. The lowest bus voltage (Bus 38) increased to 9.80 kV in this setup. To further improve the voltage profile, we added an 840 kV Ar capacitor bank at Bus 34 (the weakest bus) along with 40% PV at Bus 19. This setup reduced the active power loss by 54% and reactive power loss by 58.62%, leading to much better system performance. Overall, this study shows that placing PV units and capacitor banks at appropriate locations can improve the voltage stability and efficiency in radial distribution systems.

Keywords: Photovoltaic (PV) Integration • Power Loss Reduction • Voltage Profile • Capacitor Bank • Dig SILENT Power Factory • PV Penetration Level

1. Introduction

Global electricity demand is rising rapidly. At the same time, concerns about the environment and reducing greenhouse gas emissions are driving the shift toward renewable energy. Photovoltaic (PV) systems stand out among renewable energy sources because they generate clean energy, require little maintenance, and can be installed close to where power is used.Rooney (2023) Adding PV generation to existing power networks helps to realize more renewable energy systems.Anthony (2021) The integration of photovoltaic (PV) systems also presents new technical challenges for distribution networks. Traditional systems are designed for power to flow in one direction, from the substation to the users. In PV systems, electricity can flow in both directions.Cavus (2025) This two-way flow can change voltage levels, affect power losses, and impact feeder stability. Therefore, it is important to study the effects of different amounts of PV on the operation of dis-

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tribution networks.Bhusal et al. (2025)

Many researchers have investigated the impact of PV integration on distribution system performance. Previous studies have shown that PV systems can reduce power losses and improve voltage levels when they are properly located within the feeder. However, high PV penetration may also cause voltage rise problems, especially at buses near the PV installation.Antoniadou-Plytaria et al. (2017) Research has also shown that the location of PV units plays an important role in determining their technical benefits. The tactical placement of PV systems can help reduce losses, improve voltage regulation, and minimize the negative effects of intermittent renewable generation.Kumar et al. (2023); Shafiullah et al. (2022)

The level of PV penetration and its position within the feeder substantially affect the overall system performance. Studies have reported that PV installations near the substation usually have a smaller impact on voltage variation, whereas PV units installed at the end of the feeder may cause a greater voltage rise under high-generation conditions.Kumar et al. (2023) In many cases, installing PV units in the middle section of the feeder provides a better balance between loss reduction and voltage profile improvement.Sadiq and Antar (2024) Reactive power compensation is often used to improve the system performance. Distribution systems commonly use capacitor banks to provide reactive power and maintain acceptable voltage levels. When PV generation is combined with appropriately sized capacitor banks, both electrical stability and power losses can be improved.Trinh and Chung (2024) PV inverters can also support voltage by providing reactive power.

Simulation tools are widely used to evaluate the impact of PV integration on distribution networks. Software, such as DigSILENT Power Factory and MATLAB/Simulink, enables in-depth modelling of feeders, loads, and PV generation patterns. These tools analyse voltage variations, power losses, and system stability under different operating conditions. Previous simulation studies of radial distribution systems have demonstrated that optimal PV placement, together with reactive power compensation, can significantly improve voltage profiles and reduce system losses.Bhusal et al. (2022); Pandey et al. (2022)

This study investigates the effect of adding PV to the Bazar Feeder at the Dhulabari Distribution Centre. The analysis examines how varying the PV amounts and installation locations affect the voltage profile and feeder power losses. The PV units were tested at three locations: near the source, in the middle, and at the end of the feeder. The study also includes reactive power compensation with capacitor banks to further improve performance. The system was simulated and analysed using the DIgSILENT PowerFactory. The results provide useful guidance for the planning and operation of PV-integrated radial distribution networks.

2. Methodology

The methodology used in this study aims to evaluate the impact of photovoltaic (PV) penetration on the voltage profile and power losses of a radial distribution system. The analysis focused on the Bazar Feeder of the Dhulabari Distribution Centre. This approach includes system modelling, PV integration at different locations, and reactive power compensation to observe their effects on network performance.

The Bazar Feeder is a 38-bus radial distribution system that supplies residential, commercial, and small industrial loads. The required line and load data were collected from the distribution centre. The entire feeder was modelled using DigSILENT PowerFactory. A load-flow analysis was performed using the backward-forward sweep method, which is commonly used for radial distribution systems (Figure 2).

To study the impact of solar energy integration, different PV penetration levels were considered. In this study, PV capacities equal to 10%, 20%, 30%, and 40% of the feeder peak load were examined. These levels represent the possible stages of renewable energy integration in the distribution network. The location of the PV installation is an important factor in distribution system performance. Therefore, the PV units were placed at three different sections of the feeder. The first location was near the source, which included buses 2 to 5. The second location was in the middle part of the feeder, which included buses 18 and 19. The third location was near the end of the feeder, which included buses 34 to 38. This placement helps analyse how the PV unit position affects voltage levels and power losses along the feeder.

In addition to PV integration, reactive power compensation was applied using capacitor banks. Capacitor banks were installed on the selected buses to provide reactive power support. This helps improve the voltage profile and reduce both the real and reactive power losses in the system. The performance of the distribution network was evaluated using two main indicators: bus voltage magnitude and system power losses. The acceptable voltage range for each bus was considered to be within ±5% of the nominal value. The real and reactive power losses were calculated to determine the efficiency improvement of the feeder after PV integration and capacitor bank installation.

2.1 Study System Description

The study was conducted on the Bazar Feeder, a radial distribution feeder comprising 38 buses. The feeder supplies power to various residential, commercial, and industrial facilities. Its electrical parameters, including the line resistances, reactance's, and bus load data, were collected from the distribution center. The feeder was modelled in Dig SILENT Power Factory for a detailed load flow analysis.

2.2 Simulation procedure

The simulation process was performed in several steps to analyse the effects of PV penetration and reactive power compensation.

1. The Bazar Feeder was first modelled in the Dig SILENT Power Factory using the available line and load data.
2. A base-case load-flow analysis was performed without PV integration to obtain the reference values for the bus voltages and system power losses.
3. The PV units were then integrated at three different locations in the feeder: near the source, at the middle of the feeder, and at the end of the feeder. This was done for each PV penetration level considered in this study.
4. Load-flow simulations were performed for each scenario to evaluate the voltage profile and real and reactive power losses of the system.
5. Capacitor banks were subsequently installed at the selected buses to provide reactive power compensation, and the simulations were repeated.
6. The results from all scenarios were compared to identify the effects of the PV location, penetration level, and reactive power compensation on the distribution system performance.

This step-by-step approach allows for a clear assessment of the technical impact of PV penetration and provides useful information for the planning and operation of PV-integrated radial distribution networks (see Figure 1).

2.3 Load Flow Analysis

Load flow simulations were conducted using Dig SILENT Power Factory. The backward/forward sweep method was employed for radial systems, considering both active and reactive power flows in the system. The simulation objectives were as follows:

- To determine the voltage profile at each bus under different PV penetration levels.
- To calculate real (kW) and reactive (kVAR) power losses in the feeder.

3. Results and Discussion

This study examined the performance of a Bazar feeder with varying amounts of photovoltaic (PV) power. This feeder is a 38-bus radial network operating at 11 kV and serving a total load of 6145 kVA. For the analysis, NEA transformer peak loads were used, and industrial transformers were assumed to operate at an 80% load with a lagging power factor of 0.8. The system had several branches, and the per-unit calculations were based on 100 MVA and 11 kV. Without any PV or distributed generation, the system lost 500 kW of active power and 580 kVAR of reactive power. The voltage at Bus 1 remained at 1.0 PU, but the lowest voltage was at Bus 38, measuring 0.86 PU (9.41 kV). This indicates a clear voltage drop along the feeder, particularly at the end.

3.1 System performance at 10% PV penetration

With 10% PV penetration (540 kW), the voltage profile and power losses of the system improved. PV units were installed on different buses to assess their impact on the system. Installing the PV at Bus 4 reduced the active and reactive power losses by 4% and 5.17%, respectively. At Bus 19, the reductions were larger: 12% for active power and 13.79% for reactive power. The greatest improvement occurred when the PV was installed at Bus 38, where the losses decreased by 16% and 17.24%, respectively. In addition to reducing losses, the voltage profile also improved. When PV was installed at Bus 38, the minimum voltage increased from 9.41 kV to 9.82 kV.

3.2 System performance at 20% PV penetration

At a PV penetration of 20%(1080 kW), the network performance improved further. Installing PV at Bus 4 reduced the active and reactive losses by 8% and 10.34%, respectively (Figure 3). When PV was installed at Bus 19, the losses decreased by 24% for active power and 27.59% for reactive power (Figure 4). Installing PV at Bus 38 also led to significant reductions in losses, similar to the results for Bus 19. The voltage profile improved, and the minimum voltage at Bus 38 increased from 9.41 kV to 10.19 kV (Table 1).

3.3 System performance at 30% PV penetration

At 30% PV penetration (1620 kW), further improve at 30% PV penetration (1620 kW), the system improved even more. PV at Bus 4 reduced active and reactive power losses by 12% and 13.79%, respectively. At Bus 19, the losses decreased by 34% for active power and 36.21% for reactive power. The loss decreased by 22%, and the reactive power loss decreased by 32.76%. The minimum voltage at Bus 38 increased from 9.41 kV to 10.53 kV after PV installation.

3.4 System performance at 40% PV penetration

With a 40% PV penetration (2160 kW), the voltage profile and power losses of the feeder improved significantly. The PV at Bus 4 reduced the active and reactive power losses by 16% and 17.24%, respectively (Figure 5). The most significant improvement occurred when PV was installed at Bus 19, where the active and reactive power losses decreased by 40% and 44.83%, respectively. PV at Bus 38 also helped, reducing the active power loss by 14% and the reactive power loss by 31.03% (Figure 6). When PV was installed at the end of the feeder, the voltage at Bus 38, the weakest bus, increased from 9.41 kV to 10.84 kV (Table 2).

3.5 Effect of capacitor bank integration

To further improve the system performance, reactive power compensation was introduced using capacitor banks. To further improve the system performance, capacitor banks were added for reactive power compensation. With a 40% PV at Bus 19, the system already had significantly lower losses. In this setup, the minimum voltage at Bus 38 increased from 9.41 kV to 9.80 kV. The power losses decreased by 50% and 53.45%, respectively. The voltage profile also improved across the feeder (Table 3).

Even better results were achieved by installing an 840 kVAR capacitor bank at Bus 34, along with 40% PV at Bus 19. In this case, the active- and reactive-power losses decreased by 54% and 58.62%, respectively. The voltage profile improved across the entire feeder, resulting in the best overall performance (Figure 7). These results indicate that using both PV generation and reactive power compensation can improve voltage stability and lower system losses in radial distribution networks. analysed the impact of photovoltaic (PV) penetration on the performance of the Bazar Feeder of the Dhulabari Distribution Centre. The feeder was modelled as a 38-bus radial distribution system in DigSILENT PowerFactory, and the PV penetration levels were evaluated (see Figure 8).

The results demonstrate that integrating PV generation into the network improves the voltage profile and reduces power losses. Higher PV levels led to greater reductions in both active and reactive losses. The location where the PV system is installed also matters. In this study, placing the PV at the midpoint of the feeder (Bus 19) resulted in the greatest loss reduction. Further enhancement of system performance. The combination of 40% PV penetration at bus 19 and an 840 kVAR capacitor bank at bus 34 produced the best results, significantly reducing both active and reactive power losses while improving the voltage profile across the feeder.

The findings of this study indicate that the proper placement of PV systems and capacitor banks can significantly improve the efficiency and voltage stability of radial distribution networks. These results can guide the planning and operation of PV-integrated distribution systems.

4. Table and Figrure

Table 1: Voltage profile, with 20% PV penetration at Bazar feeder

S.N	Bus	Without PV (kV)	20% PV at Bus 4 (kV)	20% PV at Bus 19 (kV)	20% PV at Bus 38 (kV)
1	Bus_1	11	11	11	11
2	Bus_2	10.84406	10.86186	10.86485	10.86477
3	Bus_3	10.69057	10.72608	10.73206	10.73189
4	Bus_4	10.53839	10.59150	10.60047	10.60021
5	Bus_5	10.38874	10.44274	10.47128	10.47095
6	Bus_6	10.24165	10.29653	10.34454	10.34412
7	Bus_7	10.09717	10.15291	10.22026	10.21976
8	Bus_8	10.02221	10.07838	10.14625	10.14575
9	Bus_9	9.96648	10.02298	10.09124	10.09074
10	Bus_10	9.90143	9.95831	10.02703	10.02652
11	Bus_11	9.84875	9.90594	9.97502	9.97451
12	Bus_12	9.79760	9.85509	9.92454	9.92402
13	Bus_13	9.77104	9.82869	9.89832	9.89781
14	Bus_14	9.75188	9.80964	9.87941	9.87889
15	Bus_15	9.74259	9.80041	9.87024	9.86973
16	Bus_16	9.72401	9.78194	9.85190	9.85139
17	Bus_17	9.71782	9.77578	9.84579	9.84527
18	Bus_18	10.06670	10.12262	10.19628	10.19576
19	Bus_19	9.81587	9.87333	10.00945	10.00867

20	Bus_20	9.60765	9.66639	9.80548	9.84854
21	Bus_21	9.58375	9.64264	9.78207	9.82524
22	Bus_22	9.56205	9.62108	9.76081	9.80408
23	Bus_23	9.54475	9.60389	9.74388	9.78722
24	Bus_24	9.52321	9.58248	9.72278	9.76621
25	Bus_25	9.51034	9.56969	9.71017	9.75366
26	Bus_26	9.49512	9.55456	9.69527	9.73883
27	Bus_27	9.61672	9.67541	9.81437	9.86883
28	Bus_28	9.58820	9.64707	9.78644	9.86983
29	Bus_29	9.56282	9.62184	9.76158	9.87392
30	Bus_30	9.54058	9.59975	9.73981	9.88109
31	Bus_31	9.50875	9.56811	9.70863	9.90773
32	Bus_32	9.48324	9.54277	9.68366	9.94057
33	Bus_33	9.46761	9.52723	9.66835	9.95412
34	Bus_34	9.44846	9.50820	9.64960	9.99324
35	Bus_35	9.43568	9.49551	9.63709	10.03849
36	Bus_36	9.42609	9.48598	9.62771	10.08684
37	Bus_37	9.41970	9.47963	9.62145	10.13827
38	Bus_38	9.41650	9.47645	9.61832	10.19277

Table 2: Voltage profile of the Bazar feeder with 40% PV penetration

S.N	**Bus**	**Without PV (kV)**	**40% PV at Bus 4 (kV)**	**40% PV at Bus 19 (kV)**	**40% PV at Bus 38 (kV)**
1	Bus_1	11	11	11	11
2	Bus_2	10.84406	10.87928	10.88397	10.88057
3	Bus_3	10.69057	10.76089	10.77027	10.76346
4	Bus_4	10.53839	10.64368	10.65774	10.64753
5	Bus_5	10.38874	10.49578	10.54759	10.53397
6	Bus_6	10.24165	10.35042	10.43984	10.42282
7	Bus_7	10.09717	10.20763	10.33451	10.31410
8	Bus_8	10.02221	10.13353	10.26138	10.24081
9	Bus_9	9.966476	10.07845	10.20701	10.18633
10	Bus_10	9.901425	10.01415	10.14355	10.12273
11	Bus_11	9.848745	9.962076	10.09216	10.07124
12	Bus_12	9.797600	9.911523	10.04227	10.02124
13	Bus_13	9.771041	9.885272	10.01636	9.995278
14	Bus_14	9.751878	9.866332	9.997673	9.976548
15	Bus_15	9.742594	9.857156	9.988618	9.967474
16	Bus_16	9.724012	9.838791	9.970496	9.949313
17	Bus_17	9.717817	9.832668	9.964454	9.943258
18	Bus_18	10.06670	10.17753	10.31665	10.29514
19	Bus_19	9.815866	9.929736	10.19070	10.15827
20	Bus_20	9.607647	9.724037	9.990541	10.03661
21	Bus_21	9.583746	9.700427	9.967572	10.01375
22	Bus_22	9.562046	9.678992	9.946719	9.992990

23	Bus_23	9.544754	9.661911	9.930103	9.976452
24	Bus_24	9.523207	9.640628	9.909400	9.955846
25	Bus_25	9.510338	9.627917	9.897035	9.943539
26	Bus_26	9.495120	9.612884	9.882413	9.928985
27	Bus_27	9.616721	9.733004	9.999275	10.06603
28	Bus_28	9.588197	9.704830	9.971869	10.09212
29	Bus_29	9.562816	9.679760	9.947483	10.12131
30	Bus_30	9.540584	9.657802	9.926126	10.15359
31	Bus_31	9.508745	9.626356	9.895545	10.23032
32	Bus_32	9.483241	9.601168	9.871050	10.31333
33	Bus_33	9.467606	9.585727	9.856036	10.35149
34	Bus_34	9.448456	9.566814	9.837645	10.44110
35	Bus_35	9.435678	9.554196	9.825376	10.53683
36	Bus_36	9.426091	9.544728	9.816170	10.63574
37	Bus_37	9.419699	9.538415	9.810032	10.73780
38	Bus_38	9.416502	9.535258	9.806962	10.84297

Table 3: Voltage profile, with 40% PV penetration and Cap bank of 840 kvar at Bazar feeder

Scc.N	**Bus**	**Without PV (kV)**	**40% PV at Bus 19 and Cap 420 kvar at Bus 34 (kV)**	**40% PV at Bus 19 and Cap 840 kvar at Bus 34 (kV)**
1	Bus_1	11	11	11
2	Bus_2	10.84406	10.89195	10.89987
3	Bus_3	10.69057	10.78623	10.80206
4	Bus_4	10.53839	10.68167	10.70543
5	Bus_5	10.38874	10.57949	10.61116
6	Bus_6	10.24165	10.47970	10.51928
7	Bus_7	10.09717	10.38232	10.42980
8	Bus_8	10.02221	10.30958	10.35741
9	Bus_9	9.96648	10.25552	10.30360
10	Bus_10	9.90143	10.19242	10.24080
11	Bus_11	9.84875	10.14131	10.18994
12	Bus_12	9.79760	10.09170	10.14056
13	Bus_13	9.77104	10.06594	10.11492
14	Bus_14	9.75188	10.04736	10.09643
15	Bus_15	9.74259	10.03835	10.08747
16	Bus_16	9.72401	10.02033	10.06953
17	Bus_17	9.71782	10.01433	10.06355
18	Bus_18	10.06670	10.36701	10.41704
19	Bus_19	9.81587	10.26615	10.34137
20	Bus_20	9.60765	10.08567	10.18059
21	Bus_21	9.58375	10.06294	10.15807
22	Bus_22	9.56205	10.04230	10.13763
23	Bus_23	9.54475	10.02586	10.12134
24	Bus_24	9.52321	10.00538	10.10104

25	Bus_25	9.51034	9.99314	10.08892
26	Bus_26	9.49512	9.97867	10.07459
27	Bus_27	9.61672	10.09904	10.19868
28	Bus_28	9.58820	10.07682	10.18160
29	Bus_29	9.56282	10.05760	10.16750
30	Bus_30	9.54058	10.04137	10.15639
31	Bus_31	9.50875	10.02090	10.14608
32	Bus_32	9.48324	10.00645	10.14182
33	Bus_33	9.46761	10.00344	10.15113
34	Bus_34	9.44846	9.99506	10.15300
35	Bus_35	9.43568	9.98299	10.14112
36	Bus_36	9.42609	9.97394	10.13221
37	Bus_37	9.41970	9.96790	10.12626
38	Bus_38	9.41650	9.96488	10.12329

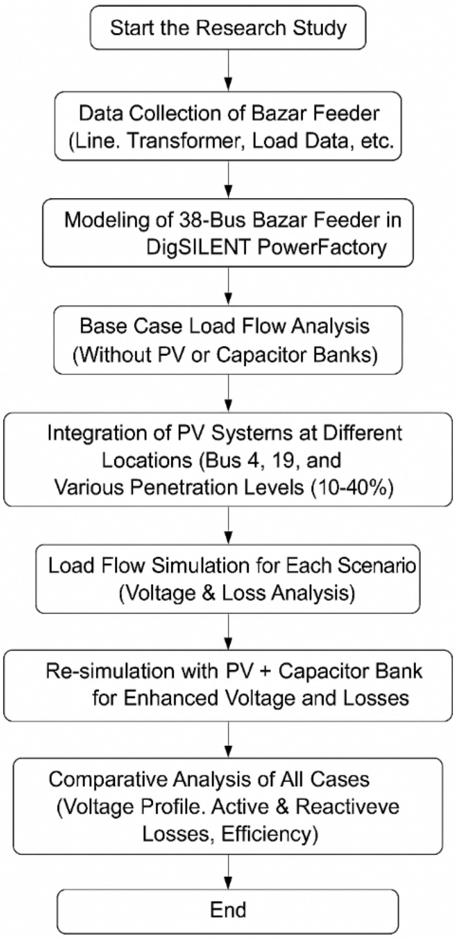

Figure 1: Methodology Flow Chart

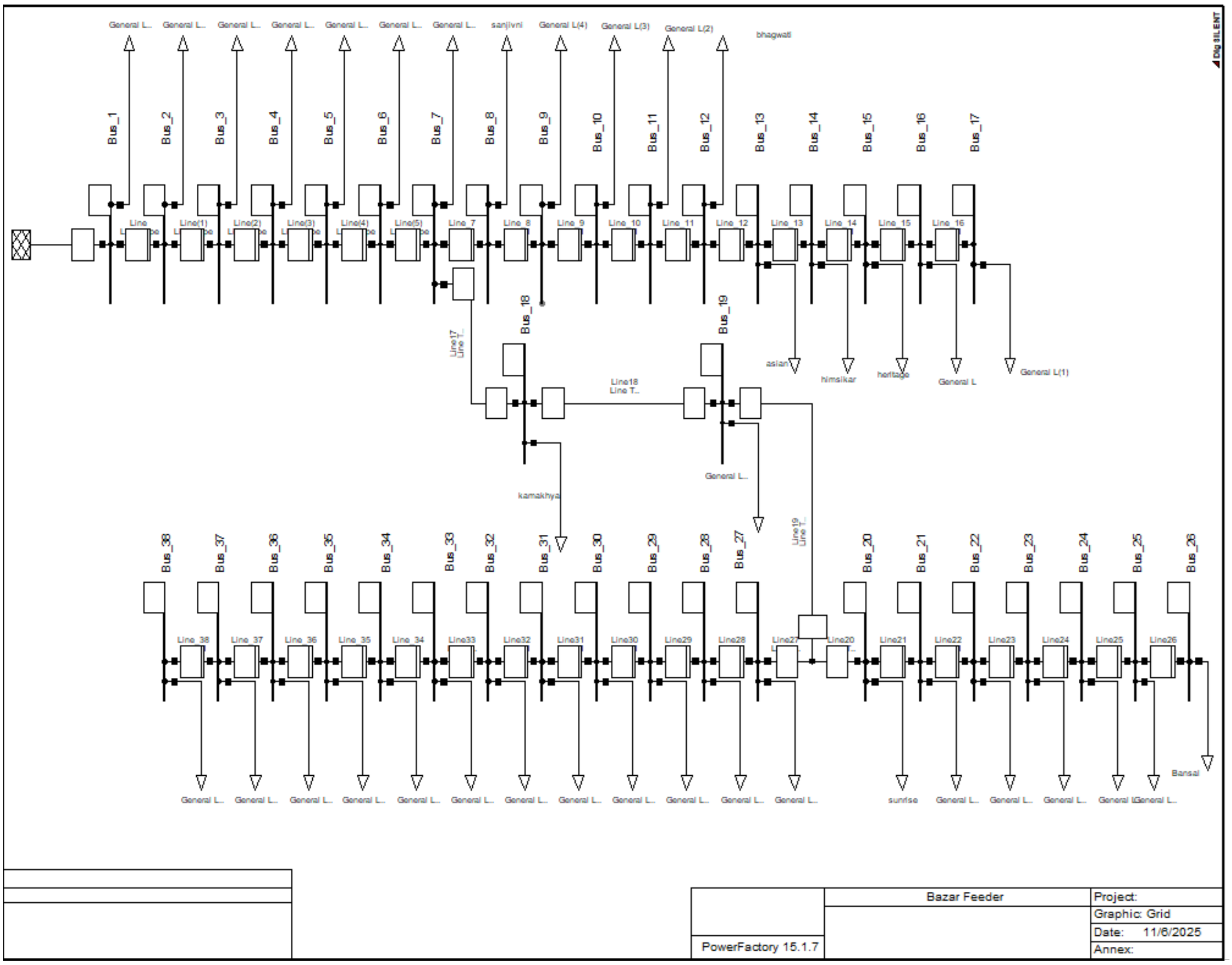

Figure 2: Dig SILENT Simulink Model of Bazar Feeder

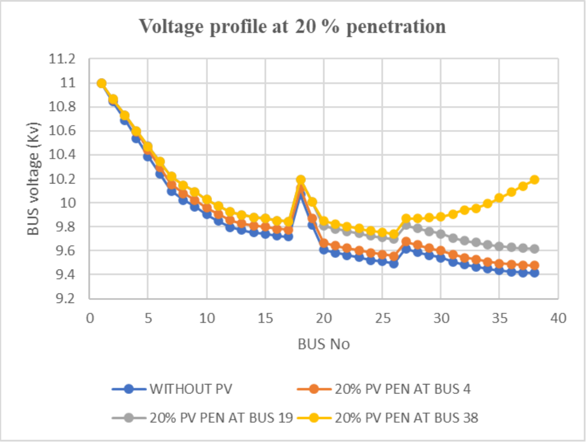

Figure 3: Voltage profile at 20% penetration

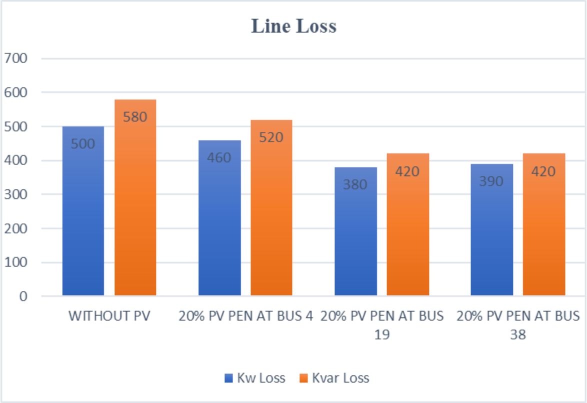

Figure 4: Line loss at 20% penetration

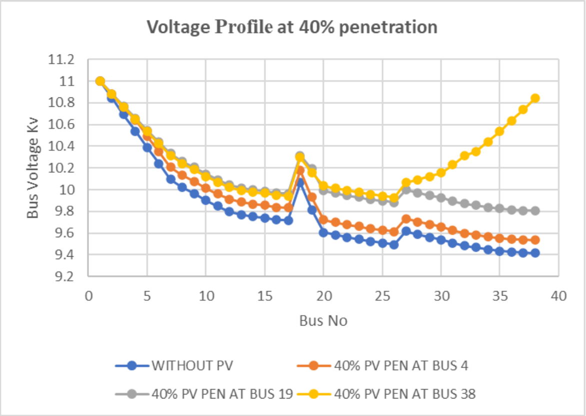

Figure 5: Voltage profile at 40% penetration

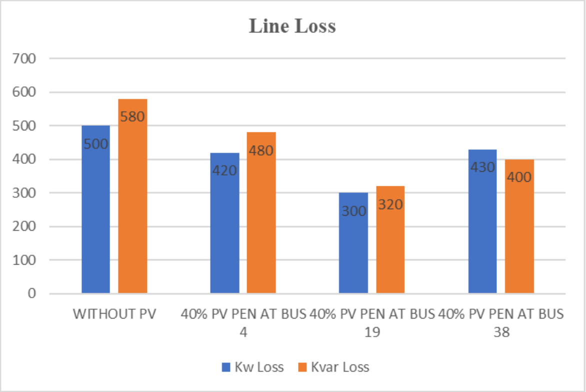

Figure 6: Line loss at 40% penetration

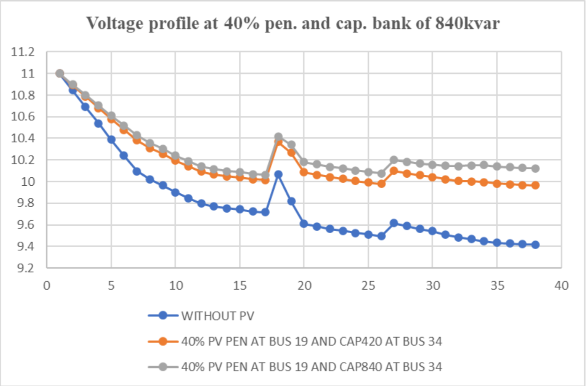

Figure 7: Voltage profile at 40% penetration and cap bank 840kvar

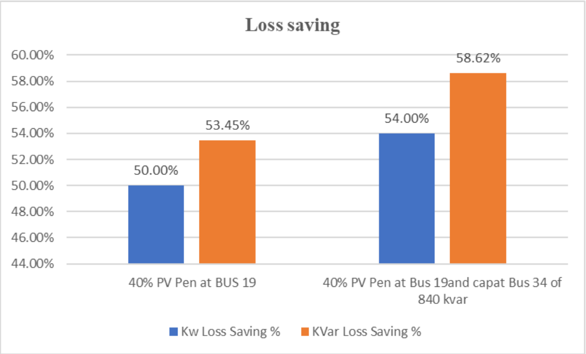

Figure 8: Loss saving % at 40% penetration and 840kvar cap bank

Conclusion

This study analyzed the impact of photovoltaic (PV) system integration on the 11 kV Bazar Feeder, a 38-bus radial distribution network in Nigeria. Load-flow analyses were conducted under various PV penetration levels, with PV systems integrated near the source (bus 4), middle (bus 19), and end (bus 38) of the feeder line. Simulations using Dig SILENT Power Factory evaluated improvements in the voltage profile and power loss. The results showed that PV integration enhanced system performance. At 10%, 20%, 30%, and 40% PV penetration levels, the active and reactive power losses were reduced, and the bus voltages were improved. At a low penetration (10%), power loss reduction was more effective with PV installation at the end bus (bus 38). However, as the penetration increased, PV placement in the middle (Bus 19) became more effective in minimizing the losses. PV integration at Bus 19 provided the maximum loss reduction, achieving 40% and 44.83% reductions in active and reactive power losses, respectively, at 40% penetration. However, the lowest bus voltage (Bus 38) remained low at 9.80 kV.

To address this issue, reactive power compensation has been introduced. Installing a 420 kV Ar capacitor bank at weak bus 34 improved the voltage profile while maintaining reduced losses. Increasing the capacitor-bank capacity to 840 kVAr with 40% PV penetration at bus 19 achieved a 54% reduction in active power loss and a 58.62% reduction in reactive power loss, with an improved voltage profile across the feeder.

Recommendations

For optimal performance in radial distribution systems, PV units should be strategically placed in the Centre of the network at higher penetration levels, whereas lower penetration levels may benefit from placement near the feeder end. Additionally, the coordinated integration of capacitor banks with PV systems is recommended to enhance voltage stability, reduce power losses, and improve overall system efficiency.

5. Author's declaration

The authors declare no conflicts of interest regarding the publication of this research paper. All contributors agreed to the final draft of the manuscript.

6. Declaration of the conflict of interest

The authors declare that there are no irreconcilable circumstances. All authors contributed to the preparation of the final manuscript.

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References

Anthony, E. J. (2021). Advances in electrical engineering, electronics and energy: Global developments in new energy technologies and development of energy technology from the micro to the macro-scale. *e-Prime - Advances in Electrical Engineering, Electronics and Energy*, 1:100026.

Antoniadou-Plytaria, K. E., Kouveliotis-Lysikatos, I. N., Georgilakis, P. S., and Hatziargyriou, N. D. (2017). Distributed and decentralized voltage control of smart distribution networks: Models, methods, and future research. *IEEE Transactions on Smart Grid*, 8:2999–3008.

Bhusal, H., Parajuli, A., Khadka, S., Sah, R., and Jha, S. K. (2025). Optimization and impact analysis of pv penetration in radial distribution system. *Journal of Electronics and Electrical Engineering*, pages 1–24.

Bhusal, H., Sah, R. K., Acharya, S., and Jha, S. K. (2022). Study on impacts of photovoltaic integration in radial distribution system. In *Proceedings of the 12th IOE Graduate Conference*, volume 8914, page 12.

Cavus, M. (2025). Advancing power systems with renewable energy and intelligent technologies: A comprehensive review on grid transformation and integration. *Electronics*, 14:1159.

Kumar, A., Verma, R., Choudhary, N. K., and Singh, N. (2023). Optimal placement and sizing of distributed generation in power distribution system: a comprehensive review. *Energy Sources, Part A: Recovery, Utilization, and Environmental Effects*, 45:7160–7185.

Pandey, S., Maharjan, A., and Bhattarai, N. (2022). Effect of photovoltaic penetration on radial distribution network: A case study of rajgadh feeder, anarmani distribution system, jhapa, nepal. In *Proceedings of the IOE Graduate Conference*, volume 8914, pages 89–95.

Rooney, W. (2023). Social, environmental, and economic consequences of integrating renewable energies in the electricity sector: a review. *Environmental Chemistry Letters*, 21:1381–1418.

Sadiq, E. H. and Antar, R. K. (2024). Minimizing power losses in distribution networks: A comprehensive review. *Chinese Journal of Electrical Engineering*, 10:20–36.

Shafiullah, M., Ahmed, S. D., and Al-Sulaiman, F. A. (2022). Grid integration challenges and solution strategies for solar pv systems: A review. *IEEE Access*, 10:52233–52257.

Trinh, P.-H. and Chung, I.-Y. (2024). Integrated active and reactive power control methods for distributed energy resources in distribution systems for enhancing hosting capacity. *Energies*, 17:1642.