Distribution System Performance through Charging Station Integration Feeder Reconfiguration and Distributed Generation to Reduce Greenhouse Gas

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ABSTRACT

This paper presents an analysis of distribution system performance through charging station, integration feeder reconfiguration, and distributed generation to reduce greenhouse gas emissions. The test system is a 33-bus distribution network, and the simulations are performed using the MATLAB. The case study is divided into five scenarios. Case 1 is the base case. Case 2 involves the installation of 10 charging stations. Case 3 applies feeder reconfiguration. Case 4 includes the installation of three distributed generation units. Case 5 includes the installation of three battery energy storage system units. The results show that installing EV charging stations causes a voltage drop in the distribution system. The feeder reconfiguration technique helps balance the load within the system, resulting in reduced power loss. The installation of distributed generation raises the voltage level at the load, thereby reducing electricity consumption from the grid. This leads to lower power losses and contributes to a reduction in greenhouse gas emissions. Power loss is reduced by 24.97% in Case 3 and by 59.09% in Case 4, compared with the Case 2 (the charging-station installation case).

Keywords: Distribution System, Charging Station, Feeder Reconfiguration, Distributed Generation, Greenhouse Gas

1. INTRODUCTION

The growing adoption electric vehicles (EV) has led to an increasing demand for charging stations, resulting in significant shifts in electricity consumption patterns particularly in urban and densely populated areas [1]. One of the key strategies to improve capability of a distribution system is application of feeder reconfiguration, which involves selecting optimal open and closed switch positions within the network. This process aims to improve supply reliability without requiring new system investments [2]. At the same time, the increasing installation of distributed generation (DG) can reduce the load on power plants, decrease feeder currents, and potentially lower power losses.

In 2009, a study was conducted to minimize power losses in a distribution system by integrating distributed generation and reconfiguring feeders. The analysis employed the Tabu Search algorithm and was tested on a 69-bus distribution system. The results demonstrated that the combination of distributed generation and feeder reconfiguration effectively reduced the overall power losses in the network [3]. In 2018, a study was conducted to evaluate the impact of electric vehicle charging station loads on voltage stability, reliability indices, energy losses, and economic inefficiencies within a distribution system. The analysis was performed using a 33-bus distribution system. The findings indicated that the integration of a fast charging station at lightly loaded buses affected the overall performance of the system [4]. In 2022, a study focused on improving voltage levels in a distribution system by deploying distributed generation in a network with reconfigured feeders. The analysis was carried out using a 69-bus distribution system in MATLAB. The simulation results showed that the installation of distributed generation helped enhance the voltage profile of the distribution system [5].

This paper discusses the integration of two techniques to improve the distribution system under an increasing number of EV charging stations. The first technique involves load balancing through feeder reconfiguration, which reduces power losses and allows the system to transfer loads to alternative feeders via tie switches. The second technique aims to raise the voltage level across the distribution network by installing distributed generation units, thereby improving the overall system voltage profile to meet standard voltage requirements. The installation of DG in a distribution system without feeder reconfiguration [6] is shown in Fig. 1. Feeder Reconfiguration and Installation of DG in a Distribution System is shown in Fig. 2

Fig. 2 shows that SS represents sectionalizing switches

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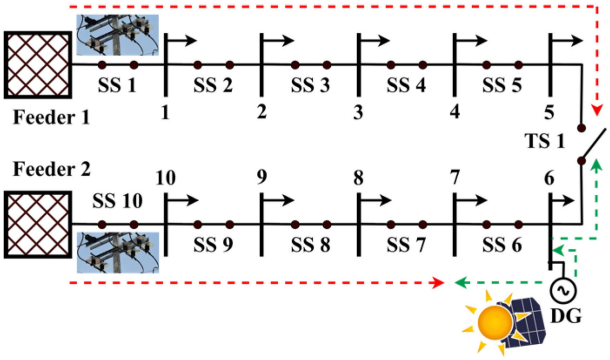

Fig. 1: Installation of DG in a Distribution System without Feeder Reconfiguration.

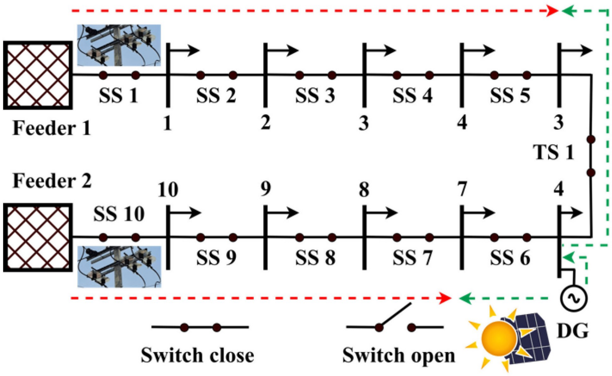

Fig. 2: Feeder Reconfiguration and Installation of DG in a Distribution System.

and TS represents tie switches. When distributed generation is installed in the system, the direction of power flow may change, as DG units inject power current to support and regulate voltage levels within the distribution network. The red dashed line represents energy generated from coal-based sources, while the green dashed line indicates energy produced from renewable sources.

2. RELATED THEORIES

2.1 Charging Station

Electric vehicles contribute to reducing carbon dioxide emissions and offer environmental benefits. However, it's important to recognize that EVs also impact the power grid, particularly by increasing peak loads and transformer power losses. The variability in charging duration and the unpredictable behaviour of EV owners can further affect the overall efficiency and stability of the distribution system. Simultaneous charging of a large number of electric vehicles can lead to an increase in peak energy demand [7]. The effects of electric vehicle charging infrastructure on power system operations are illustrated in Fig. 3.

The rapid growth in electric vehicle adoption has created a rising need for public charging stations capable of delivering faster charging speeds. Along highways,

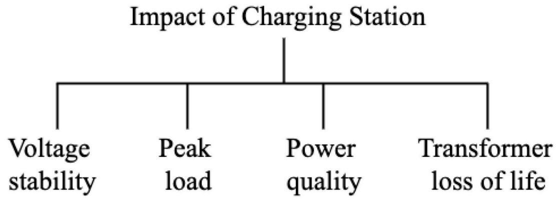

Fig. 3: Effects of Electric Vehicle Charging Infrastructure on Power System Operations [9].

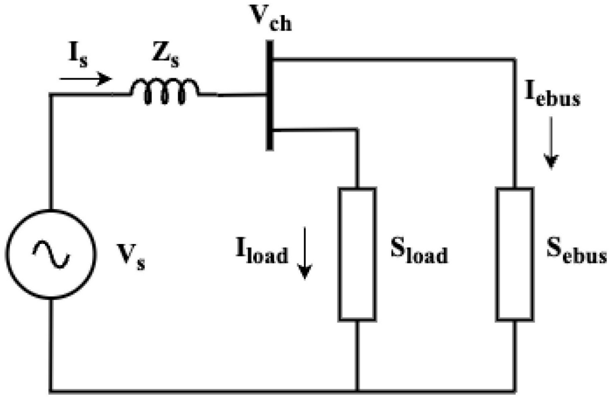

Fig. 4: Equivalent Circuit of a Charging Station [11.

high-demand charging stations are commonly found, as high-speed travel typically requires fast charging.

As a result, these fast-charging stations deliver electricity at higher power levels compared to standard charging stations [9].

Impact on voltage: The integration of EVs into the distribution system can cause voltage drops at buses during charging periods. To maintain system reliability, voltage levels must remain above 95% of the nominal value (0.95 p.u.) [10].

Impact on energy loss: Energy losses in the power system become a critical concern as energy demand rises. With increased EV charging, power losses in the distribution system also increase. Strategically positioning EV charging stations can help minimize these losses and improve overall system efficiency. The equivalent circuit of a charging station is illustrated in Fig. 4.

The electric current at a bus equipped with an EV charging station can be estimated using Equation (1).

$$\begin{aligned} I_L &= I_{Load} + I_{ebus} \\ &= \left(\frac{P_{ebus} + jQ_{ebus}}{V_{ch}}\right)^* + \left(\frac{P_{Load} + jQ_{Load}}{V_{ch}}\right)^* \end{aligned} \tag{1}$$

The charging voltage for electric vehicle buses can be determined using Equation (2).

$$V_{ch} = V_s - \left(R_s + jX_s\right) I_s \qquad ; I_s = I_L. \tag{2}$$

2.2 Balance Load

Feeder reconfiguration involves modifying the network topology by opening or closing tie switches.

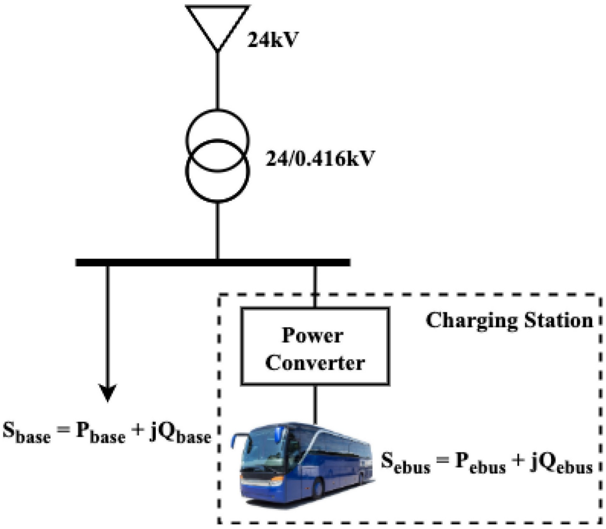

Fig. 5: Schematic Diagram of Charging Station [12]

This process must adapt to dynamic changes in load conditions with the goal of minimizing energy losses and alleviating overloading within the network [13]. Through this process, loads can be transferred from one feeder to another. Periodic reconfiguration is necessary because each feeder typically serves a variety of load types, requiring adjustments to maintain efficient and reliable operation [14]. A distribution network typically employs two categories of switches: sectionalizing switches, which are normally closed, and tie switches, which are normally open. These switches play a key role in network protection and in managing system configuration management [15]. The operation of feeder reconfiguration in a distribution system is illustrated in Fig. 6.

2.3 Impact of Distributed Generation

The installation of DG in a distribution system can significantly influence power flow and voltage levels experienced by end-users. Its positive impacts include enhanced system reliability, improved voltage support, and better overall power quality [16-17]. A two-bus representation of the distribution system is shown in Fig. 7.

Fig. 8 shows that distributed generation provides a compensatory power supply to the load, resulting in less power being produced by the main generator.

Since the load complex power is represented as $S_L = P_L + jQ_L$, [18] the corresponding current drawn by the load can be calculated using Equation (3)

$$I_L = \frac{(P_L - jQ_L)}{3V_P} \tag{3}$$

A two-bus model of the distribution system with DG installed between the source bus and the load bus is shown in Fig. 8.

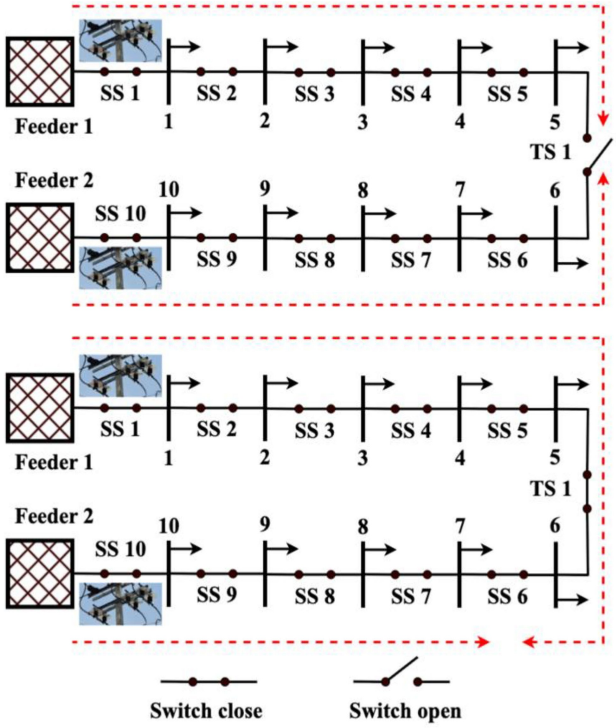

Fig. 6: Operation of Feeder Reconfiguration in a Distribution System.

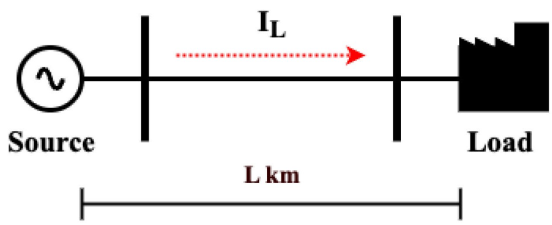

Fig. 7: Two-Bus of the Distribution System.

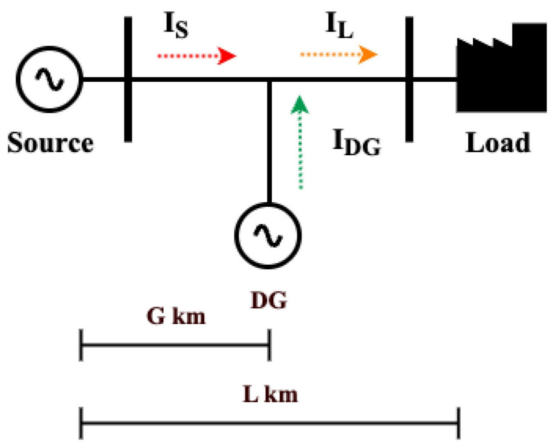

Fig. 8: Two-Bus of Distribution System with DG Installed between the Source and the Load Buses.

2.4 Calculation of Greenhouse Gas Reduction

The calculation of greenhouse gas (GHG) emissions is conducted in accordance with the guidelines of Thai-

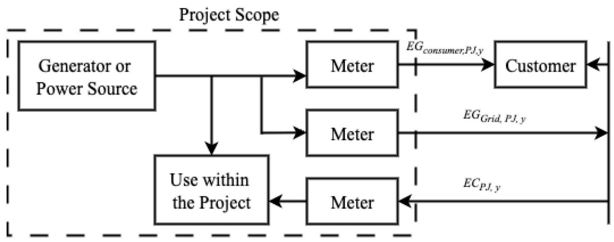

***Fig. 9**: Diagram of Parameters for Electricity Generation for Self-Consumption, Sale or Supply to Other Operators, and Delivery to the Transmission System.*

land's Voluntary Emission Reduction Program (T-VER) [19-20]. The reduction in greenhouse gas emissions can be calculated using Equation (4).

$$ER_y = BE_y - PE_y - LE_y \tag{4}$$

where ER_y represents the volume of GHG emissions reduced as a result of the scheme implemented in year, BE_y refers to emissions of baseline emissions in year y, PE_y indicates the actual emissions from the project in year y, and LE_y denotes the GHG emissions occurring outside scheme boundary in year y.

It is assumed to remain constant over the duration analyzed in this study. The value of PE is considered to be zero, as the greenhouse gas reduction project does not involve the use of fossil fuels or electricity. The diagram of parameters for electricity generation for self-consumption, sale or supply to other operators, and delivery to the transmission system is shown in Fig. 9.

$$\begin{aligned} BE_y &= BE_{EG,\ y} \\ &= (EG_{consumer,\ PJ,\ y} \times 10^{-3}) \times EF_{EC,\ PJ,\ y} \\ &+ (EG_{Grid,\ PJ,\ y} \times 10^{-3}) \times EF_{EG\_RE,\ PJ,\ y} \end{aligned} \tag{5}$$

where $BE_{EG,\ y}$ is the quantity of GHG emissions resulting from fossil fuel–based based production of electricity in year y (tons of carbon dioxide equivalent per year), $EG_{consumer,PJ,y}$ refers to total electricity generated for self-consumption, delivery, or sale to end-users from the project in year y (kWh/year), $EF_{EC,\ PJ,\ y}$ is the factor of emission factor associated with electricity consumption in year y (tCO_2eq/MWh), $EG_{Grid,\ PJ,\ y}$ refers to the quantity of electricity generated and supplied to the transmission system from renewable energy projects in year y (kWh/year), and $EF_{EG\_RE,\ PJ,\ y}$ is GHG emission factor for production of electricity from renewable energy in year y (tCO_2eq/MWh).

2.5 Power Loss Calculation

The variables of the two-bus distribution system model are shown in Fig. 10.

Fig. 10 shows two buses interconnected via branch i, with its resistance and reactance represented by R_i and X_i, respectively [21]. Power losses can be calculated

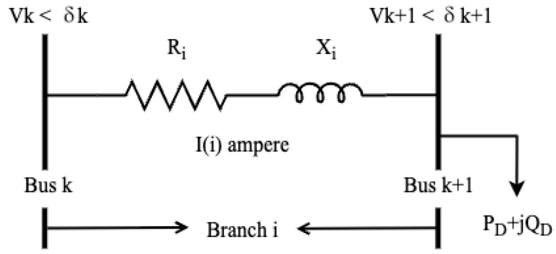

***Fig. 10**: Variable of the Two-Bus Distribution System Model.*

using Equations (6) and (7).

$$P_{Loss(i)} = R_i \times \frac{P_{k+1}^2 + Q_{k+1}^2}{\left|V_{k+1}\right|^2} \tag{6}$$

$$Q_{Loss(i)} = X_i \times \frac{P_{k+1}^2 + Q_{k+1}^2}{\left|V_{k+1}\right|^2} \tag{7}$$

where $P_{Loss(i)}$ and $Q_{Loss(i)}$ represent the active and reactive power losses in branch i, respectively.

The total power loss in the system can be determined using Equation (8).

$$P_{Loss\ Total} = \sum_{i=1}^{no.\ of\ Branch} P_{Loss(i)} + Q_{Loss(i)} \tag{8}$$

3. CASE STUDY

In this paper, a 33-bus radial distribution system is used. All sectionalizing switches (Switches 1 through 32) are initially set to the closed position, while tie switches (Switches 33 to 37) remain open. The system under test carries a total load of 3,715 kW of active power and 2,300 kVAr of reactive power. Branches 1 to 9 have a maximum current capacity of 400 A, while the other branches, including the tie lines, are constrained to a maximum current of 200 A. Voltage levels across the network must remain between 0.95 and 1.00 per unit (p.u.). The 33-bus distribution system is shown in Fig. 11.

Fig. 11 shows loads in distribution system divided into three types: viz small, medium, and large. Small loads with capacities between 1-100kW (Bus 2, 3, 5, 6, 9-13, 15-23, 26-28 and 33). Medium loads with capacity between 101-200 kW (Bus 4, 7, 8, 14 and 29-31). Large load capacity more than 200 kW (Bus 24, 25, and 32).

Details of the case study are provided below:

Case 1: The distribution system operates without charging station, DG and balancing load.

Case 2: The distribution system is installed charging station.

10 charging stations are installed in the distribution network. The installed capacities of the charging stations in the distribution system are shown in Table 1.

Table 1 shows the capacity of the charging stations, which are divided into three sizes: small, medium, and **large** load. The small-load charging station has

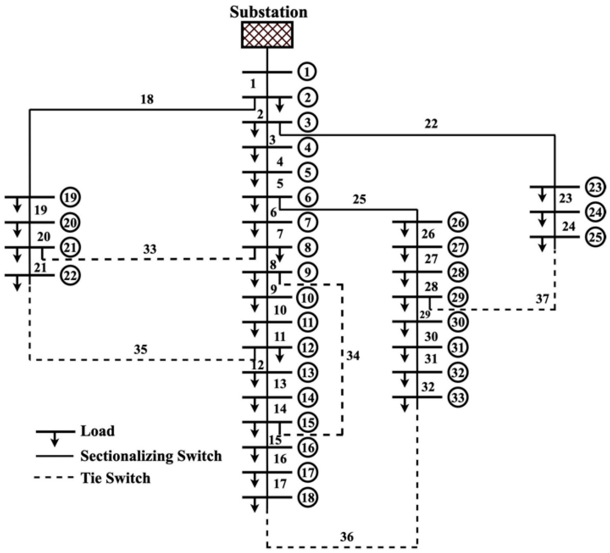

***Fig. 11**: The 33-Bus Distribution System.*

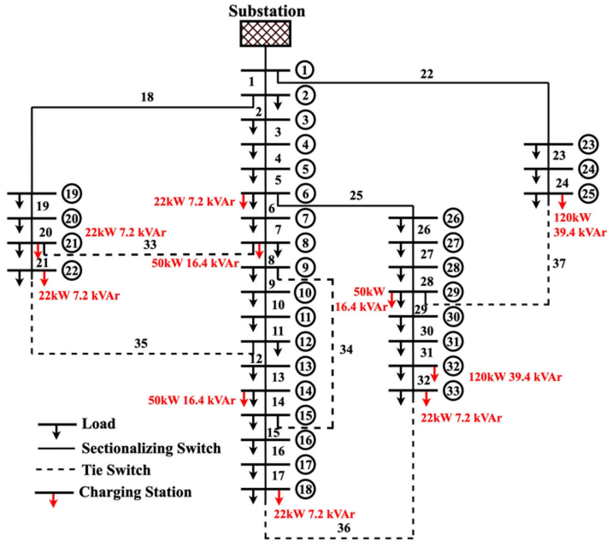

***Fig. 12**: Distribution System with the Installed Charging Station.*

***Table 1**: The Installed Capacities of the Charging Stations in the Distribution System.*

Bus	Type of Load	Capacity	
		P (kW)	Q (kVAr)
6	Small	22.00	7.20
8	Medium	50.00	16.40
14	Medium	50.00	16.40
18	Small	22.00	7.20
21	Small	22.00	7.20
22	Small	22.00	7.20
25	Large	120.00	39.40
29	Medium	50.00	16.40
32	Large	120.00	39.40
33	Small	22.00	7.20

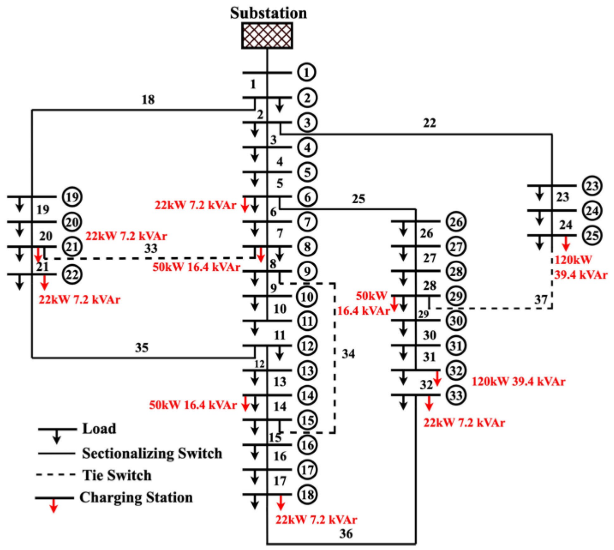

***Fig. 13**: Distribution System with the Installed Charging Stations and Feeder Reconfiguration.*

a capacity of 22 kW and 7.2 kVAr. The medium-load charging station has a capacity of 50 kW and 16.4 kVAr. The large-load charging station has a capacity of 120 kW and 39.4 kVAr. All three sizes of charging stations represent types of charging stations currently used in Thailand. The distribution system with the installed charging stations is shown in Fig. 12.

Case 3: The distribution system includes both charging station installation and feeder reconfiguration.

In this case, the analysis is extended from Case 2. Two types of switches are operated: sectionalizing switches and tie switches. The distribution system with the installed charging stations and feeder reconfiguration is shown in Fig. 13.

Fig. 13 shows that sectionalizing switches 11 and 32 are open, while tie switches 35 and 36 are closed.

Case 4: The distribution system includes charging station installation, feeder reconfiguration (DG), and distributed generation. In this case, the analysis is extended from Cases 2 and 3. Three DG units are installed at Buses 29, 32, and 33 with capacities of 300, 500, and 200 kW, respectively. The distribution system with the installed charging stations, feeder reconfiguration, and distributed generation is shown in Fig. 14.

Case 5: The distribution system includes charging station installation, feeder reconfiguration, and battery energy storage system (BESS) installation. In this case, the total system load is reduced to 0.7 p.u, and the analysis is extended from Cases 2 and 3. Three BESS units are installed at Buses 18, 25, and 30 with capacities of 400 kW, 600 kW, and 300 kW, respectively. The distribution system with the installed charging stations, feeder reconfiguration, and BESS units is shown in Fig. 15.

Fig. 15 shows that when the time changes to sunset, the distributed generation units cease operation; therefore, the battery energy storage system (BESS) is

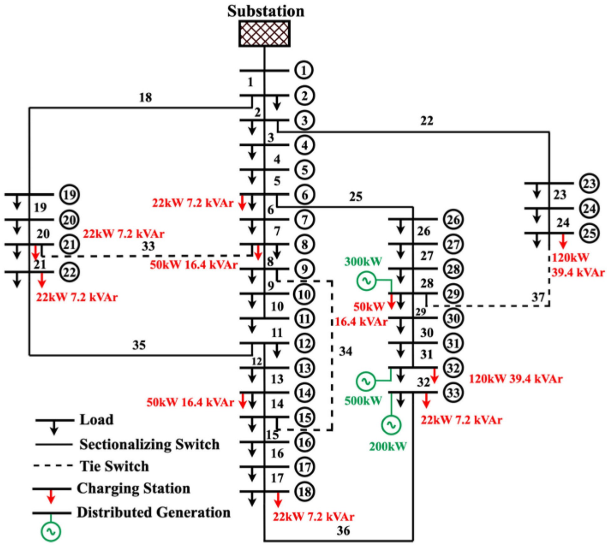

***Fig. 14**: Distribution System with the Installed Charging Stations, Feeder Reconfiguration, and Distributed Generation.*

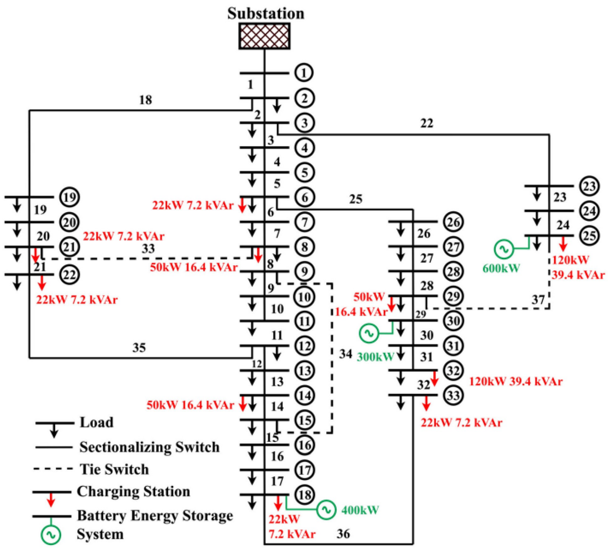

***Fig. 15**: Distribution System with Charging Stations, Feeder Reconfiguration, and Battery Energy Storage Systems.*

utilized. A BESS unit is installed at Bus 18 because it is located on a long feeder. Another unit is installed at Bus 25 due to its high EV load and because the end of the feeder carries a large total load. The BESS installed at Bus 30 supports the feeder end, where the load is high and a voltage drop occurs.

4. RESULTS

The load balancing of each lateral in the distribution system achieved using the feeder reconfiguration technique is shown in Table 2.

The results of power loss in case 1, 2 and 3 are shown in Table 3.

***Table 2**: The Load Balancing of Distribution System Laterals Using the Feeder Reconfiguration Technique.*

Laterals	Before FR		After FR	
	P (kW)	Bus	P (kW)	Bus
1 (Middle)	1649	1-18	1067	1-11
2	404	19-22	1068	12-22, 33
3	1050	23-25	1050	23-25
4	1112	26-33	1030	26-32

***Table 3**: The Results of Power Loss in Case 1, 2 and 3.*

	Case		
	1	2	3
Power loss (kW)	202.61	265.23	199.08
Power loss (kVAr)	135.12	177.64	141.91
Min voltage bus	18	18	32
Min voltage (p.u.)	0.913	0.901	0.920
Loss reduction (%)	-	-30.96	24.94

***Table 4**: The Results of Power Loss in Case 4 and 5.*

	Case	
	4	5
Power loss (kW)	108.49	50.47
Power loss (kVAr)	79.23	35.22
Min voltage bus	18, 33	32
Min voltage (p.u.)	0.953	0.958
Loss reduction (%)	59.09	80.98

Table 3 shows the loss reduction in Case 2 compared to Case 1, and the loss reduction in Case 3 compared to Case 2. The results of power loss in Cases 4 and 5 are shown in Table 4.

Table 4 shows the loss reduction in Cases 4 and 5 compared to Case 2. In case 4, three DG units are installed at buses 29 (300kW), 32 (500kW) and 33 (200kW), reducing greenhouse gas emissions by 51.27, 85.45, and 34.18 tCO_2eq per year, respectively. The voltage results are indicated in Table 5.

Table 5 shows the minimum-voltage bus in Cases 1, 2, 3, 4, and 5 as follows: Case 1: Bus 18 (0.913 p.u.), Case 2: Bus 18 (0.901 p.u.), Case 3: Bus 31 (0.881 p.u.), Case 4: Bus 30 (0.952 p.u.), and Case 5: Bus 32 (0.958 p.u.)

The voltage comparison between Cases 1 and 2 is shown in Fig. 16.

The voltage comparison between Cases 2 and 3 is shown in Fig. 17.

Voltage comparison between Cases 2 and 4 is shown in Fig. 18.

The voltage comparison between Cases 2 and 5 is shown in Fig. 19.

The comparison of the results with [12] for the case with installed charging stations is shown in Table 6.

***Table 5**: The Result of Voltage.*

Bus	Case Study				
	1	2	3	4	5
1	1.000	1.000	1.000	1.000	1.000
2	0.997	0.997	0.997	0.997	0.999
3	0.983	0.981	0.984	0.987	0.992
4	0.975	0.972	0.977	0.983	0.989
5	0.968	0.964	0.971	0.979	0.985
6	0.950	0.943	0.956	0.968	0.976
7	0.946	0.939	0.954	0.966	0.975
8	0.941	0.933	0.951	0.964	0.974
9	0.935	0.926	0.950	0.962	0.973
10	0.929	0.920	0.949	0.961	0.972
11	0.928	0.919	0.949	0.961	0.972
12	0.927	0.917	0.959	0.966	0.985
13	0.921	0.910	0.951	0.960	0.984
14	0.918	0.907	0.948	0.958	0.983
15	0.917	0.906	0.946	0.957	0.983
16	0.916	0.904	0.944	0.956	0.984
17	0.914	0.902	0.940	0.954	0.984
18	0.913	0.901	0.939	0.954	0.985
19	0.997	0.996	0.995	0.996	0.998
20	0.993	0.992	0.981	0.984	0.992
21	0.992	0.991	0.978	0.981	0.991
22	0.992	0.990	0.972	0.977	0.989
23	0.979	0.977	0.980	0.983	0.991
24	0.973	0.969	0.972	0.975	0.99
25	0.969	0.965	0.968	0.971	0.99
26	0.948	0.940	0.954	0.967	0.975
27	0.945	0.937	0.951	0.965	0.974
28	0.934	0.924	0.938	0.959	0.968
29	0.926	0.914	0.930	0.955	0.963
30	0.922	0.910	0.926	0.953	0.962
31	0.918	0.905	0.921	0.951	0.959
32	0.917	0.903	0.920	0.951	0.958
33	0.917	0.903	0.939	0.954	0.985

***Table 6**: Comparison of The Results with [12] for the Case with Installed Charging Stations.*

	This paper	Ref. [12]
Capacity of charging station (kW)	500	300
Min voltage (p.u.) at bus	0.9010 (18)	0.8139 (18)
Power loss (kW)	265.23	183.14

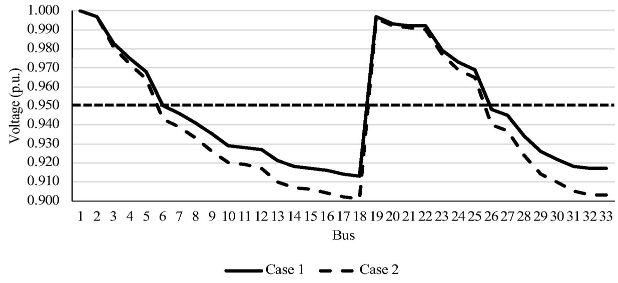

***Fig. 16**: Voltage Comparison Between Case 1 and 2.*

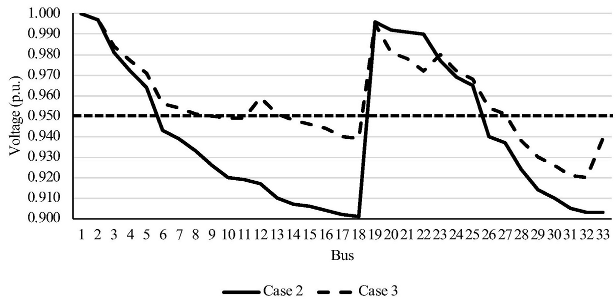

***Fig. 17**: Voltage Comparison Between Cases 2 and 3.*

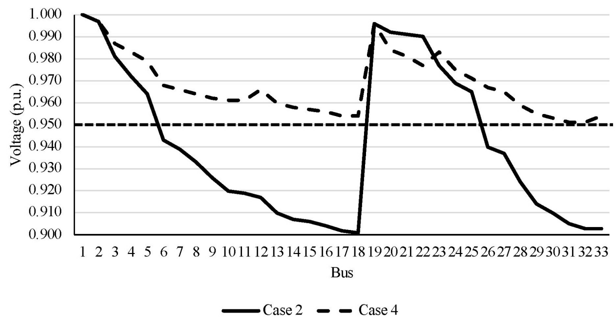

***Fig. 18**: Voltage Comparison Between Cases 2 and 4.*

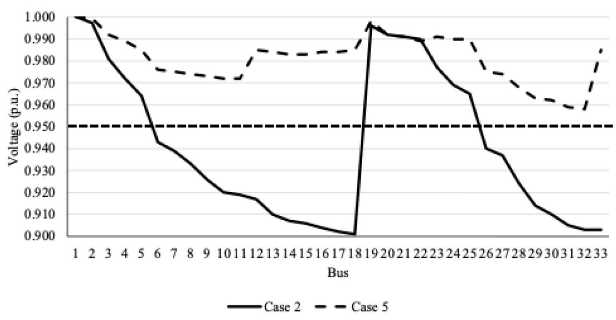

***Fig. 19**: Voltage Comparison Between Cases 2 and 5.*

5. CONCLUSION

This paper presents distribution system performance through the integration of charging stations, feeder reconfiguration, and distributed generation to reduce greenhouse gas emissions. The test system is a 33-bus distribution network, and the simulations were performed using MATLAB. The results showed that installing charging stations caused a voltage drop at the minimum-voltage bus (151.92 V), and increased power loss by 30.96%. The feeder reconfiguration technique, which helps balance the load in the distribution system, reduced power loss by 24.97%. After applying feeder reconfiguration, the load variation decreased, with only a 3.56% difference between the highest and lowest values. The installation of DG units raised the voltage level at the load, thereby reducing electricity consumption from the grid and subsequently decreasing power loss. In Case 4, DG units were installed at Bus 29 (300 kW), Bus 32 (500 kW), and Bus 33 (200 kW), resulting in greenhouse gas reductions of 51.27, 85.45, and 34.18 tCO_2eq per year, respectively.

Future work will apply this method to optimally determine the suitable locations for charging station installation in distribution systems.

ACKNOWLEDGEMENT

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APPENDIX

Table AI: *Load Data of the 33-Bus Distribution System [22].*

Bus No.	P_L (kW)	Q_L (kW)	Bus No.	P_L (kW)	Q_L (kW)
2	100	60	18	90	40
3	90	40	19	90	40
4	120	80	20	90	40
5	60	30	21	90	40
6	60	20	22	90	40
7	200	100	23	90	50
8	200	100	24	420	200
9	60	20	25	420	200
10	60	20	26	60	25
11	45	30	27	60	25
12	60	35	28	60	20
13	60	35	29	120	70
14	120	80	30	200	600
15	60	10	31	150	70
16	60	20	32	210	100
17	60	20	33	60	40

Table AII: *Branch Data of the 33-Bus Distribution System [22].*

Branch No.	Sending end bus	Receiving end bus	R (Ω)	X (Ω)
1	1	2	0.0922	0.0470
2	2	3	0.4930	0.2512
3	3	4	0.3661	0.1864
4	4	5	0.3811	0.1941
5	5	6	0.8190	0.7070
6	6	7	0.1872	0.6188
7	7	8	0.7115	0.2351
8	8	9	1.0299	0.7400
9	9	10	1.0440	0.7400
10	10	11	0.1967	0.0651
11	11	12	0.3744	0.1298
12	12	13	1.4680	1.1549
13	13	14	0.5416	0.7129
14	14	15	0.5909	0.5260
15	15	16	0.7462	0.5449
16	16	17	1.2889	1.7210
17	17	18	0.7320	0.5739
18	2	19	0.1640	0.1565
19	19	20	1.5042	1.3555
20	20	21	0.4095	0.4784
21	21	22	0.7089	0.9373
22	3	23	0.4512	0.3084
23	23	24	0.8980	0.7091
24	24	25	0.8959	0.7071
25	6	26	0.2031	0.1034
26	26	27	0.2842	0.1447
27	27	28	1.0589	0.9338
28	28	29	0.8043	0.7006
29	29	30	0.5074	0.2585
30	30	31	0.9745	0.9629
31	31	32	0.3105	0.3619
32	32	33	0.3411	0.5302
		Tie Switch		
33	8	21	2.0000	2.0000
34	9	15	2.0000	2.0000
35	12	22	2.0000	2.0000
36	18	33	0.5000	0.5000
37	25	29	0.5000	0.5000

REFERENCES

[1] S. Nasri, N. Mansouri, A. Mnassri, A. Lashab, J. Vasquez, and H. Rezk, "Global Analysis of Electric Vehicle Charging Infrastructure and Sustainable Energy Sources Solutions," *World Electric Vehicle Journal*, vol.16, no.4, pp. 194, Mar. 2025.

[2] B. Vena, and K. Reddy, "Distribution Network Reconfiguration via Metaheuristic Optimization Techniques," in *2025 33rd Southern African Universities Power Engineering Conference (SAUPEC)*, Pretoria, South Africa, 2025, pp. 1-6.

[3] N. Rugthaicharoencheep, and S. Sirisumrannukul, "Feeder Reconfiguration for Loss Reduction in Distribution System with Distributed Generators by Tabu Search," *GMSARN International Journal*, vol.3, no. 2, pp. 47-54, 2009.

[4] S. Deb, K. Tammi, K. Kalita, and P. Mahanta, "Impact of Electric Vehicle Charging Station Load on Distribution Network," *Energies*, vol.11, no.1, pp. 178, Jan. 2018.

[5] N. Ruangsap, S. Nedphokaew, and N. Rugthaicharoencheep, "Planning and Operation Enhanced Voltage Profile by Using Distributed Generators Installation in Distribution System with Feeder Reconfiguration," in *2022 International Conference on Power, Energy and Innovations (ICPEI)*, Pattaya Chonburi, Thailand, 2022, pp. 1-4.

[6] L. P. Zanchetta, and L. L. Pfitscher, "Studies on the reconfiguration on distributed networks with distributed generation," in *2015 50th International Universities Power Engineering Conference (UPEC)*, Stoke on Trent, UK, 2015, pp. 1-5.

[7] C. Sehrawat, S. Mittal, K. Shokeen, and G. Singh, "Demand Study and Impact of Electric Vehicle on grid system in Delhi," in *2024 International Conference on Sustainable Technologies in Civil and Environmental Engineering (ICSTCE 2024)*, 2024, pp. 1-14.

[8] S. Deb, K. Kalita, and P. Mahanta, "Review of impact of electric vehicle charging station on the power grid," in *2017 International Conference on Technological Advancements in Power and Energy (TAP Energy)*, Kollam, India, 2017, pp. 1-6.

[9] Q. Liu, H. Fang, J. Wang, and S. Yan, "The Impact of Electric Vehicle Charging Station on the Grid," in *International Conference on Applied Science and Engineering Innovation (ASEI 2015)*, pp. 1459-1462, 2015.

[10] D. Srinivas, and M. R. Reddy, "Optimal Placement of Electric Vehicle Charging Station by Considering Dynamic Loads in Radial Distribution System," in *2022 International Conference on Automation, Computing and Renewable Systems (ICACRS)*, Pudukkottai, India, 2022, pp. 212-217.

[11] B. Boribun, P. Paolaor, and T. Kulworawanichpong, "Impact of electric bus charging in power distribution systems," in *The 2013 World Congress on Advances in Nano, Biomechanics, Robotics, and Energy Research (ANBRE13)*, Seoul, Korea, 2013, pp. 561-568.

[12] T. Boonraksa, A. Paudel, P. Dawan, and B. Marungsri, "Impact of Electric Bus Charging on the Power Distribution System a Case Study IEEE 33 Bus Test System," in *2019 IEEE PES GTD Grand International Conference and Exposition Asia (GTD Asia)*, Bangkok, Thailand, 2019, pp. 819-823.

[13] F. Amin, S. Sarjiya, M. Isnaeni BS, and W. Y. Atmaja, "Network Reconfiguration Strategies for Reducing Network Losses Under High PV Penetration," in *2024 16th International Conference on Information Technology and Electrical Engineering (ICITEE)*, Bali, Indonesia, 2024, pp. 352-357.

[14] M. A. Kashem, V. Ganapathy, and G. B. Jasmon, "Network reconfiguration for load balancing in distribution networks," *IEE Proc.-Gener. Trunsm. Distrib*, vol. 146, no. 6, pp. 563-567, Nov. 1999.

[15] P. V. V. Rama Rao, and S. Sivanagaraju, "Radial Distribution Network Reconfiguration for Loss Reduction and Load Balancing using Plant Growth Simulation Algorithm," *International Journal on Electrical Engineering and Informatics*, vol. 2, no. 4, pp. 266-277, Nov. 2010.

[16] N. Rugthaicharoencheep, and M. Boonthienthong, "Smart grid for energy management on distribution system with distributed generation," in *2012 IEEE International Conference on Cyber Technology in Automation, Control, and Intelligent Systems (CYBER)*, Bangkok, Thailand, 2012, pp. 165-169.

[17] P. Kritavorn, T. Lantharthong, and N. Rugthaicharoencheep, "The combined loss reduction approach to apply in distribution system with distribution generation," in *TENCON 2014 - 2014 IEEE Region 10 Conference*, Bangkok, Thailand, 2014, pp. 1-5.

[18] P. Chiradeja, "Benefit of Distributed Generation: A Line Loss Reduction Analysis," in *2005 IEEE/PES Transmission & Distribution Conference & Exposition: Asia and Pacific*, Dalian, China, 2005, pp. 1-5.

[19] N. Rugthaicharoencheep, N. Ruangsap, S. Nedphokaew, "Shortening the Payback Period of Greenhouse Gas Reduction Benefits from Photovoltaic Rooftop Systems," *Energies*, vol.17, no. 23, pp. 6159, Dec. 2024.

[20] United Nations Framework Convention on Climate Change, "ACM0002: Grid-connected electricity generation from renewable sources — Version 22.0," in *United Nations Framework Convention on Climate Change (UNFCCC)*, May. 2024.

[21] N. M. Nor, A. Ali, T. Ibrahim, and M. F. Romlie, "Battery Storage for the Utility-Scale Distributed Photovoltaic Generations," *IEEE Access*, vol.6, pp. 1137 – 1154, Nov. 2017.

[22] S. H. Dolatabadi, M. Ghorbanian, P. Siano, N. D. Hatziargyriou, "An Enhanced IEEE 33 Bus Benchmark Test System for Distribution System Studies," *IEEE Transactions on Power Systems*, vol. 36, no. 3, pp. 2565–2572, May. 2021.

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